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Marine Fisheries REVIEW

On the cover: A tagged striped marlin ready for release. See the article beginning on page 63.

Articles

July-August-September 1983, 45(7-8-9)

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Toward an Improved Seafood Nomenclature System

ROY E. MARTIN, WILLARD H. DOYLE, and
JAMES R. BROOKER

Introduction

The Complexity Problem

Historically, names have been given to certain fish through centuries-old biological or local populace identification procedures (Leudtke, 1973). Names such as ratfish, hoki, croaker, and whiptail were attributed to certain species with no regard for consumer appeal or the edibility characteristics of the fish (Goode, 1884). Reliance on this type of identification and its transfer to products which contain these species, has been the practice in considering "common or usual name" designations in the labeling regulations of the U.S. Food and Drug Administration (USDI, 1954).

Until recently, fishermen have had to sort by hand the most desirable fish from the others netted in the same catch. Advances in on-board processing techniques in removing the edible meat have increased the value of many species that were formerly discarded because of small size and bones. At present, edible meat can be removed from a mixed catch directly without hand sorting. A wide variety of products can be made from the recovered meat (Martin, 1972, 1974, 1976, 1980, 1981; Federal Register, 1975; USDC, 1975). This is one of the areas of greatest potential expansion for fishery products.

The marketplace for food products has changed drastically in the past few decades. Based on improved processing capabilities, there has been tremendous growth in the number of processed food products in the marketplace, with seafood products representing about 10 percent of the total.

Methods for marketing food products have also changed. The food industry has moved from the cracker-barrel age to a point where almost all products are processed, packaged, and highly advertised. The marketplace has evolved from "mom and pop" grocery stores to chain stores, supermarkets, hypermarkets, and shopping malls. Every new product must fight for recognition. Effective product names and product identification are a necessity, with the nomenclature of such products playing a significant role in their commercial success or failure.

The seafood industry produces a more bewildering array of species and products than any other food industry, with new species and products finding their way into the marketplace at an ever-increasing rate (Fig. 1).

The nomenclature of other groups of animals that provide muscle protein are simple, because they involve fewer species (Fig. 2). However, food fish in the United States alone encompass some 500 different species and worldwide, more than 1,000 species have been marketed, each one with its own individual "common or usual" name (Fig. 2). Not infrequently, the same species will have different names depending upon its geographic location. For example, the species *Morone saxatilis* is called "rockfish" in Maryland, and "striped bass" in California (Cohen, 1969).

The Regulatory Problem

The U.S. Food and Drug Administration (FDA) has the authority to interpret and enforce food labeling provisions which are contained in the Food, Drug, and Cosmetic Act (FDA, 1979). These provisions cover seafood, but no specific section applies to seafood products. As a result, legislation, procedures, interpretations, and advisory opinions of the agency applied to seafood are the same

ABSTRACT—The world demand for protein is continually increasing, and seafoods, which are high in protein as well as other essential nutrients, are being sought in greater numbers. However, many traditional species are in short supply, and new fishery management plans must be implemented to preserve and rebuild the remaining resource for future use. But this shortage also helped to expand the market for underutilized species.

Marketability of these species is difficult because many of them have names that are unfamiliar and inappropriate for advertising purposes. For this reason, a comprehensive project is being developed to implement a new system for establishing market names for fishery products based on their edibility characteristics. This system will have a major positive impact on fishery products in the marketplace, with benefits to consumers, the industry, and regulatory agencies.

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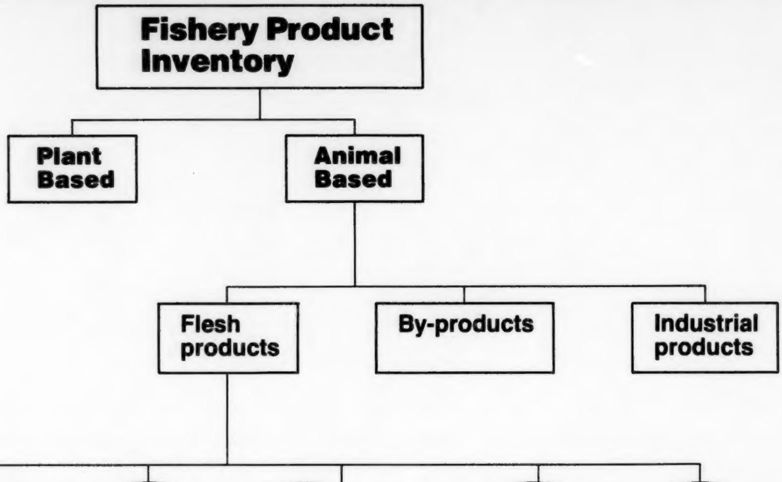

	Fresh	Frozen	Canned	Cured	Dried
Made from whole fish	Drawn fish Dressed and boned fish Whole fish Butterfly fillets Fish steaks Live shellfish	Dressed fish Fish steaks Breaded fish sticks Fish fillets	Fish in sour cream Fish chunks Fish in soybean oil Rolled fillets of fish with capers Kippered snacks Deveined shellfish	Marinated fish Spiced fish Silver-cured fish Pickled fish Smoked fish	Klipfish Freeze-dried shellfish Fish flour Freeze-dried fish
Made from fillet blocks		Fish sticks Frozen and breaded portions			
Made from minced flesh		Fish sticks Fish portions Shrimpos Shellfish sticks	Fish balls in bouillon Salted fish cakes Fish pies with mixed potatoes Fish pudding Fish dumplings Shellfish cakes	Shellfish sausage Fish wieners Fish ham	

Figure 1.—Product versatility.

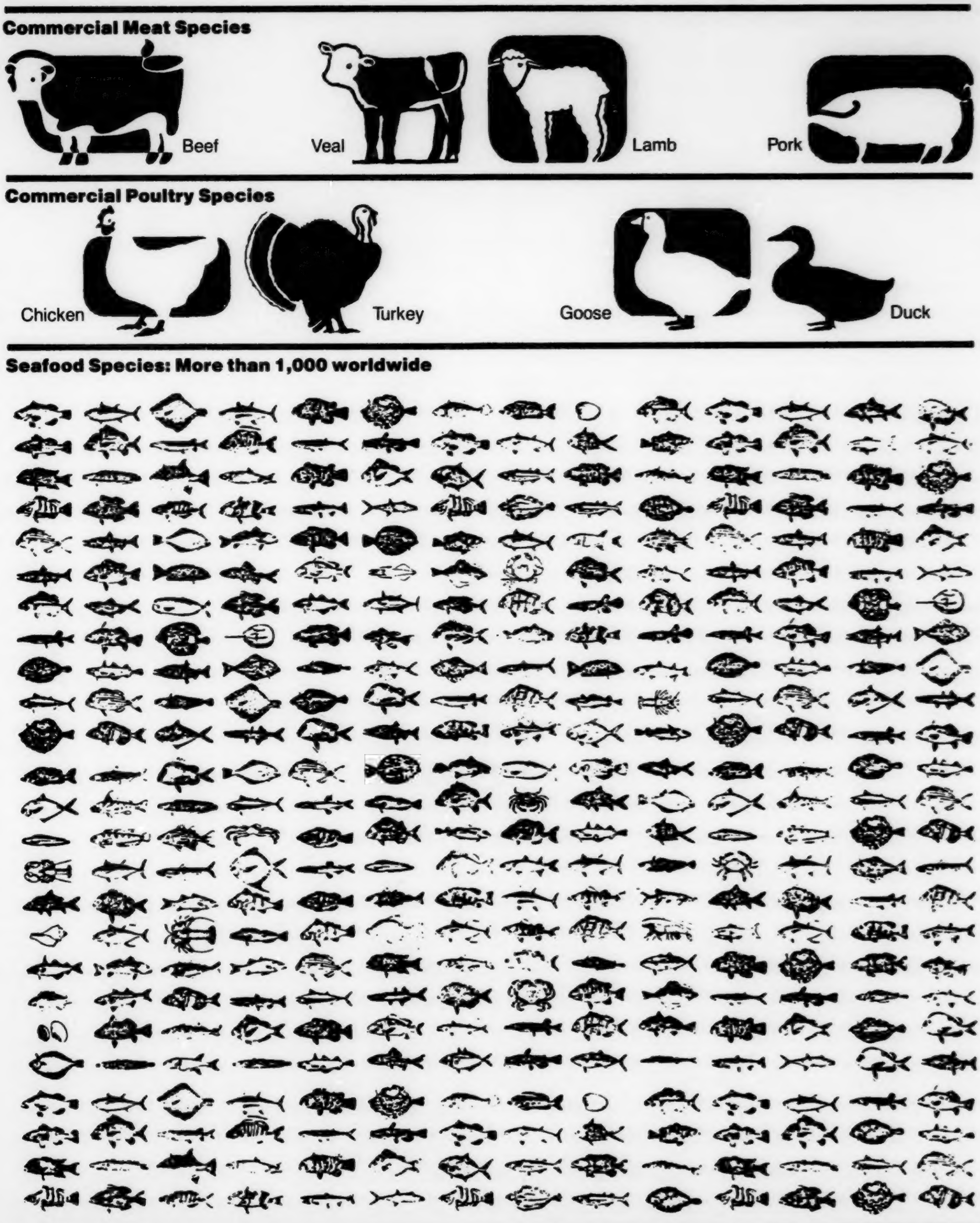

Figure 2.—Pictorial complex of the basic problem.

as those for most other food products (Federal Register, 1975). However, due to the large number of species, the forms of presentation, and formulated products, industry development and marketing efforts are frustrated in the absence of clear, consistent labeling and compliance guidelines.

The intent of the Act is to ensure that labels carry sufficient and accurate information to enable consumers to shop intelligently, and to protect consumers from economic deception (U.S. Supreme Court, 1924). The FDA has, as a result of past court decisions, formed some general guidelines, though not clearly defined, as to which factors are important in considering the common or usual name of a product. Significant among these factors are: "(1) The name should have traditional usage, that is, it should be customary, prevailing, universal, and popular; (2) a strongly established name cannot be changed and has a 'proven right' over a proposed new one (a name is considered to be strongly established if it has gained general acceptance through 'long usage'); (3) when an established name exists, a new name should not be such that it gives the manufacturer an unfair competitive advantage or upsets a well established balance of competition in the marketplace; (4) the name should take into account cultural and aesthetic inclinations of the American public, as well as considerations of health, value, and quality; and (5) the name should not create confusion in the marketplace."

Presently, common names for fish species contain little or no useful information for the consumer. They are used in reference to the species in a product, not the product itself. Consequently, the consumer knows very little about the edibility or physiological characteristics of the product and the large variety of seafoods available to them. They confine their purchases to a few familiar items, burdened by many negative misconceptions that their confusion has created.

The basic concepts used in making seafood nomenclature decisions are confused and unclear (FDA, 1970). Some of these which have been particularly troublesome are outlined below.

Common or Usual Name of the Food

This phrase is part of the Food, Drug, and Cosmetic Act. Its intention is to relate to names familiar to consumers. As interpreted relative to seafood products labeling, it is frequently and incorrectly confused with the common name of a fish or shellfish. The common name of a fish is not the same as the "common or usual name of a food." For most seafood products there is no common or usual name.

Traditional names

The common name of a finfish or shellfish is the name used in day to day conversation by fishermen, consumers, sportsmen, etc. Some fish have as many as 50 common names from almost as many different locations (Fig. 3). Many popular commercial fish have several common names, and this creates much of the confusion in the marketplace (Schoning[1]). In most cases, common names provide little or no useful information to consumers; in others, unattractive names (i.e., ratfish, wolffish, etc.) prevent marketing of an otherwise desirable species.

Some states, such as California, Oregon, and Washington have adopted, through their state legislatures, names for marketing certain species of fish common to their coastline for intrastate use (CDFG, 1974). These names are not recognized outside California, and present FDA regulations allege that products so labeled would be deemed misbranded if marketed outside of California. However, Canada has approved some market designations of West Coast species which are similar to those approved by the state of California (Campbell, 1979).

Scientific names

Scientific names are assigned by means of systematic zoology, and cannot be used for market identification since their Latinized versions (International Congress of Zoology, 1964) convey nothing to either the consumer, processor, or food scientist. Their use of comparative anatomy has been as a reference in the biological identification of species, and that designation is ultimately used in an attempt to find a common name from a particular part of the historical zoological literature.

Lists

The National Marine Fisheries Service (NMFS) has, since the mid-1930's, published a glossary of common species names for finfish, crustaceans, and mollusks (USDC, 1978a). The American Fisheries Society (AFS) has also published lists of fishes along with their common names (Robins et al., 1980), and the Organization for Economic Cooperation and Development (OECD) has an excellent multilingual dictionary of fish and fish products (OECD, 1968). FAO is also generating lists of names of fishes for the various fishing areas of the world. It is important to note here that none of these, and other independent lists, have received official recognition by the FDA, relative to use in labeling foods. However, the FDA does consult the AFS list from time to time when questions arise regarding the labeling of some species.

Nomenclature problems relate to a wide variety of labeling and regulatory issues that have been a continuing impediment to the seafood industry for quite some time, and present significant obstacles to future fisheries development (Federal Register, 1973; USDC, 1979b; Jernudd and Thuan, 1980). Without satisfactory solutions, confusing nomenclature impedes workable communications and understanding, thereby foiling effective marketing efforts (Brooker[2]).

The actual number of fishery products available is well beyond the grasp of the average consumer. No other food category involves such a diversity of product variations dealing with nomenclature. The problem of naming products for

[1]Schoning, R. W. 1974. National Marine Fisheries Service, NOAA, Washington, D.C. Pers. commun.

[2]Brooker, J. R. 1977. Memo of meeting with FDA officials to consider a name change from Pacific Hake to Pacific Whiting. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Wash., D.C.

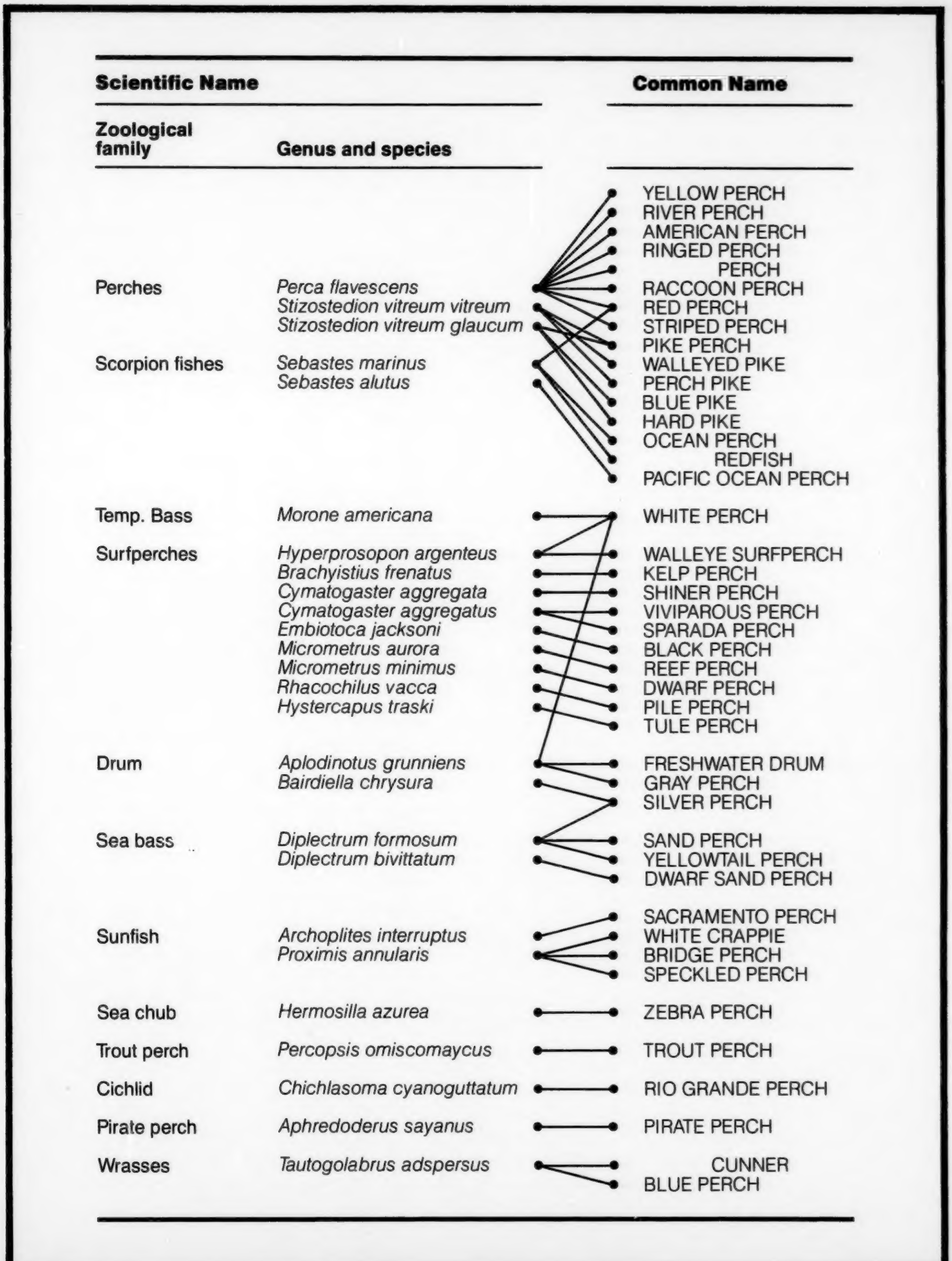

Figure 3.—Confusion between scientific and common names.

both regulators and the industry becomes exceedingly difficult and confusing considering the size of the system to be managed and understood. This complexity makes it extremely difficult to market new fishery resources and products effectively and inhibits domestic development as well as world trade in seafood products. Based on improved processing techniques and increased access to resources, there is significant potential for expanding seafood industry markets and per capita seafood consumption. Without a logically and properly developed nomenclature system for seafoods, the benefits of increased landings and consumption cannot reach their full potential.

Interpreting the Act has resulted in a multitude of intricate problems for both the seafood industry and the FDA (Schnably[3]). Traditionally, nomenclature problems have been handled on a case-by-case basis and decisions are slow in promulgation (Anonymous, 1947, 1979a; Federal Register, 1968, 1970, 1979a,b; Farrell, 1972; Brooker[4], footnote 2). It has become clear that a case-by-case approach offers no solution to the problem. A more comprehensive approach is necessary.

From the sources identified above, the seafood industry must create a unique nomenclature system that can be effective in marketing seafood products while not violating the requirements of the Food, Drug, and Cosmetic Act. In keeping its product development and marketing efforts consistent with consumer interests and the law, the industry is frequently faced with resolving nomenclature conflicts and finds its efforts frustrated in the absence of clear guidelines or standards appropriate to the complexities of fishery nomenclature. An objective in resolving this problem would be to reduce the number of common names so that each seafood species has only one market name. A "market name" refers to the name by which a fish or product will be known for labeling purposes. This concept has not yet acquired full recognition under present labeling laws.

Within our present nomenclature matrix, we have one or more of the following problems: 1) Too many terms—more than one term for a particular purpose, 2) not enough terms—an essential component which has not been given appropriate terminology, 3) unfamiliar terms—the same term used for different purposes, 4) misleading terms—causes attention to be diverted in the wrong direction, and 5) unattractive terms—aesthetically unpleasant in context of food products.

There is a limit to the number of names the consumer can assimilate. It is necessary to reduce the number of common names if we are going to try and bring a greater number of underutilized species into the protein and food needs of the world. This could be accomplished if similar food fish could be legally identified with a group name for marketing and labeling purposes.

"Nomenclature" is defined in "Webster's Third New International Dictionary" as: "A system or a set of names or designations used in a particular science, discipline, or art and formally adopted or sanctioned by the usage of its practitioners" (Gove, 1969:1534).

This definition includes three important principles: 1) The need for an organized, comprehensive system of names; 2) the development of a nomenclature system for the convenience of its users; and 3) the formal adoption of such a system. The seafood industry, food regulators, and consumers constitute a body of practitioners who need their own nomenclature system. Since an effective system does not currently exist, one must be constructed.

The first task in building a model nomenclature system was to delineate that information which is essential for accurately identifying fishery products. Various kinds of information which are necessary for product identification can be grouped into three broad categories for convenience: 1) Species, 2) product forms, and 3) product modifications. When distinctions are made among fish, important characteristics emerge (i.e., flavor, color, odor, boniness, texture, and moistness), but no broad framework was available from which to perceive similarities among species. An exploratory study found that the consumer is unable and unwilling to memorize "common names" beyond a small number of species, and focus group research reinforced these findings (USDC, 1974c).

This primary search uncovered what are now designated as "Comparative Edibility Factors" (USDC, 1974d). It will generally be recognized that more than one biological species of fish offer similar characteristics. Various properties taken together comprise a grouping and species commercially underdeveloped could fall into groups that exhibit similar natural and physical characteristics ("comparative edibility" rather than "comparative anatomy"). Figure 4 represents an illustration of that point. "Semantic noise" has to be simplified because as common names have accumulated over the years, so have words and phrases which describe their product forms and modifiers.

An identification system is based on sorting different species (i.e., cod and flounder) into several groups by using chosen base criteria (characteristics). It is a different kind of scheme with different objectives than other sorting/labeling programs such as food grading. Grading programs are more concerned with classification based on quality attributes rather than edibility characteristics. Product identification is the most basic labeling function because it tells you the "what" of your intended purchase. Design of an identification system is made difficult by the need to confine information on the label to the minimum necessary to do an effective job of communicating the identity of the product to the consumer.

A three-tier model was developed for testing. Fishery products fall into three broad groups: 1) Those which require identification of an individual fish, 2) those which require identification of a similar group of fish, and 3) those which require identification of dissimilar or mixed group of fish (Fig. 5).

Current identification is a single tier system, evolved around the traditional

[3]Schnably, J. R. 1972. Bureau of Foods, U.S. Food and Drug Administration, Washington, D.C. Pers. commun.
[4]Brooker, J. R. 1975. National Marine Fisheries Service, NOAA, Washington, D.C. Pers. commun., 22 Dec.

Factors	Sea herring	Northern anchovy	Blueback herring	Atlantic herring	Pacific alewives	Pacific herring	Spanish sardine	Pacific sardine	Pilchard sardine	Maine sardine	Brisling sardine	Atlantic thread herring	Atlantic alewives
Natural Moisture	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST	MOIST
Moisture after cooking	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
Oil content	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL	HIGH
Texture	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
Flake size	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Flavor quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Very Good	Good	Good
Flavor intensity	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
Color of meat (tone)	off white	off white	off white	off white	off white	off white	off white	off white	off white	off white	off white	off white	off white
Color of meat (hue)	DARK WT.	DARK WT	DARK WT	DARK WT	DARK WT	DARK WT	Grey	Grey	Grey	Grey	Grey	DARK WT	DARK WT
Overall quality of meat	MED	MED	MED	MED	MED	HIGH	MED	MED	MED	MED	LOW	HIGH	MED
Body size	Small	Small	Small	Small	Small	Small	Small	Small	Small	Small xSmall	xSmall	Small	Small
Body shape	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND	Semi RND
Quantity of bones	Little	Little	Little	Little	Little	Little	Little	Little	Little	Little	Little	Little	Little
Hardness of bones	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft
Is boning difficult?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bones a problem?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bones edible when cooked?	YES	NO	NO	NO	NO	NO	Yes	Yes	Yes	Yes	Yes	NO	NO
Bone size	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL	x SMALL
Cooking-fry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cooking-bake	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Cooking-boil/steam	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Figure 4.—Fish factor matrix—a basis for sorting.

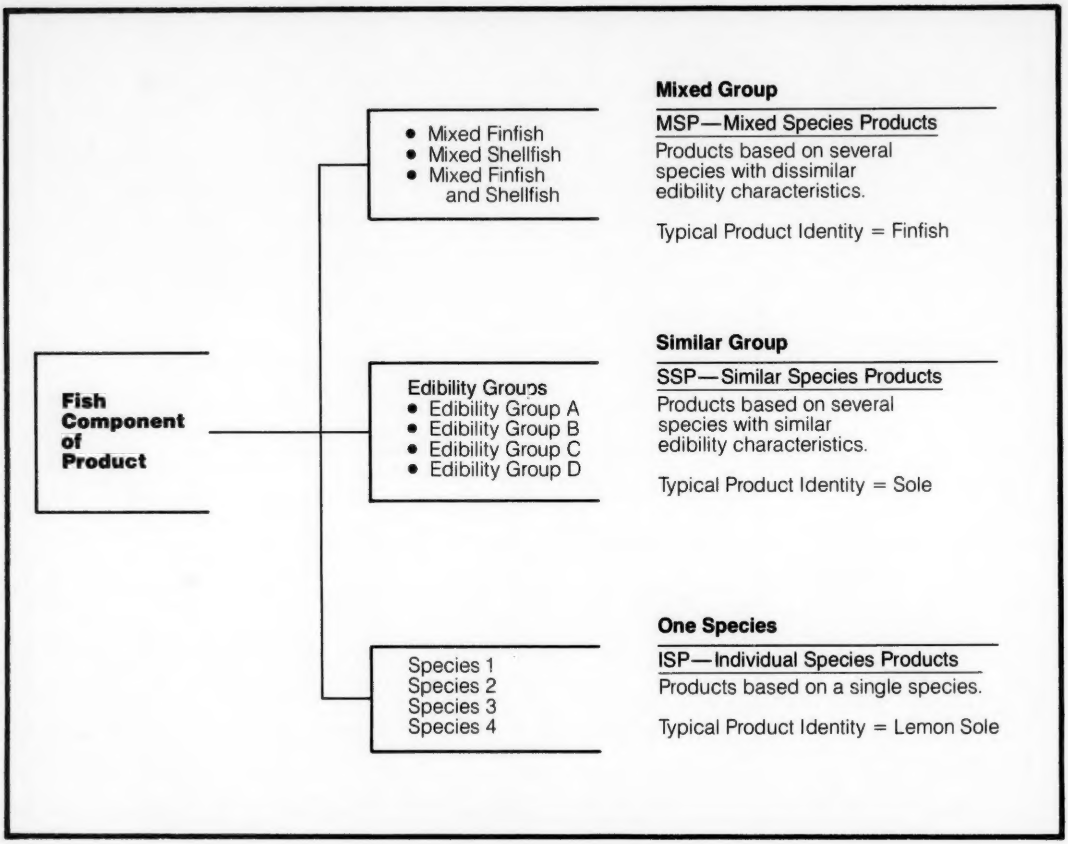

Figure 5.—Three-tier identity framework based on the mix of product and edibility characteristics.

common name of a single fish approach.

Under the experimental model, Tier I would include products made from one fish or one species, a pattern which closely resembles that of the existing common name approach. With this model, precise identification of individual fish is possible.

Tier II would identify products which contain meat from fish within a similar group. Fish within this group are basically similar in sensory properties. Each separate group would have a different name and the total number of groups would be limited to 20 or 25 (Britt[5]).

Tier III products would contain fish of more than one group (dissimilar) and be identified by an appropriate generic term. The number of generic terms would, of necessity, be kept small. Other regulatory requirements would be met by including in the label ingredient information about the mixture if determined to be necessary.

Edible differences among species tend to average out and become less important when going from the Tier I to the Tier III level. Differences among individual species are most important at the Tier I level and relatively unimportant at the Tier III level.

An added economic benefit to the industry became apparent early in the study since packaging inventory requirements would be reduced and brought into better control under this new scheme. The nature of the seafood industry often presents itself with species of fish that temporarily become unavailable because of bad weather at sea, foreign upheavals, reduced fishing quotas, and unavoidable environmental accidents. Using a grouping concept would eliminate the need for a multitude of single species labels and packages that now exist under present common or

[5]Britt, S. H. 1975. School of Marketing, Northwestern University, Evanston, Ill. Pers. commun.

usual name regulations.

Product forms and modifiers were also considered in the initial phase of study since their terminology related to a particular class of information about fishery products (Fig. 6). Product identification can be related to a combination of elements from three structured groups of nomenclature: Species, product forms, and their modifiers (Fig. 6). We can then begin to align common names with properties of the fish which relate to their food qualities.

The matrix of this system is flexible enough to encompass every type and variation of fishery product while simple enough to be learned and used easily and quickly. We view the results of this research in the following forms.

A. Benefits for Consumers:
1. Makes shopping for seafood species and products easier.
2. Provides useful information.
3. Chances of satisfaction with a purchase are increased.
4. Opens up many more choices and alternatives.
5. Simplifies understanding of preparatory methods.
6. Implementation of a seafood identification system will provide consumers with a system that will significantly increase the use of aquatic species as a primary source of food.

B. Benefits for Industry:
1. Enables industry to provide alternative species, when necessary, which reduces pressure on stocks of familiar fish.
2. Simplifies quality control, import and export specifications, and compliance with government regulations.
3. Reduces regulatory restrictions and improves relations with those agencies.
4. Simplifies the introduction and marketing of new species and products.
5. Reduces inconsistencies and confusion in industry communications and labeling; and saves time and costs.
6. Helps enhance a positive public image for the industry.
7. Enables the seafood industry to compete more effectively with other food industries for consumer dollars.
8. Problems are eased for retailers who can provide better information to shoppers, for stock clerks, and for buyers and brokers in ordering and shipping.

C. Benefits for Regulatory Agencies:
1. Having a comprehensive system and guidelines simplifies the regulatory process.
2. Helps clarify labeling issues that are currently confused and provides a basis for improvement in key aspects of legislation/regulations.
3. Provides a model for product identification in other categories.

Each section of the identification system will have a distinct series of nomenclature associated with it. For example, a set of "market names" will be developed to identify "individual species" of fish. Each element of nomenclature will have to be clearly defined and guidelines provided to standardize its use. Clear definition and consistency in application will resolve many of the problems which currently exist.

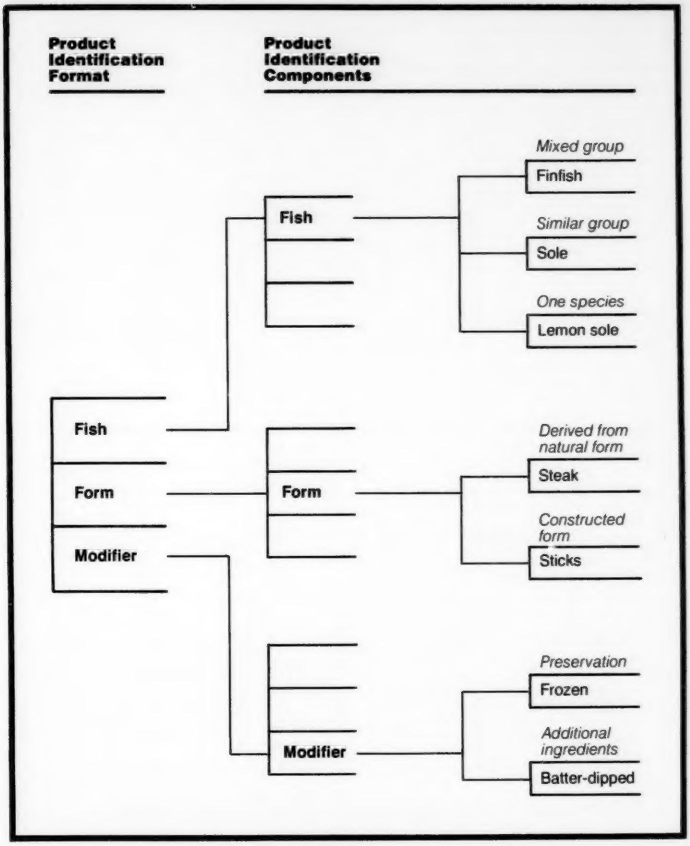

Figure 6.—Product identification components.

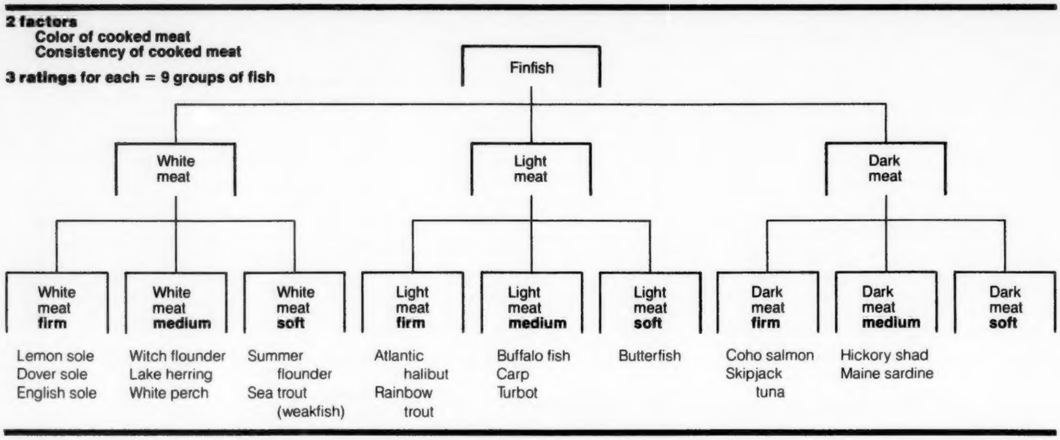

Figure 7.—Color and texture factor complex.

1. Are bones a problem?
( ) Yes
( ) Sometimes (Depends on product use)
( ) No

2. Is the fish difficult to bone?
( ) Very
( ) Somewhat
( ) Not very

3. Are the bones edible after cooking?
( ) Yes
( ) Depends on process
( ) No

4. How many bones are present?
( ) Few
( ) Medium
( ) Many

5. How large are the bones?
( ) Very small
( ) Small
( ) Medium small
( ) Medium
( ) Medium large
)) Large

6. How hard are the bones?
( ) Soft
( ) Medium
( ) Hard

Figure 8.—Bone factor complex.

When completed, the identification system will provide a simple and effective method of product identification and labeling. Detailed guidelines for use will be provided to the industry.

To quote from tradition: "There's no such fish as scrod in the ocean." Scrod was dreamed up by a Boston maitre d'. He was determined to serve the freshest daily catch from returning schooners, but it was anybody's guess which fish would find itself on the top of the hold after the boats had been out 10 days—cod, haddock or pollock. Since menus were printed a day in advance, "scrod" was coined to make sure the very best from the latest catch was served.

NMFS, in its role of providing technical and marketing assistance to the fishery industry and conducting consumer education programs, proposed to organize and coordinate an effort to clarify existing marketing nomenclature and provide improved procedures for establishment or change of seafood naming. If successful, this effort would expand the use of underutilized resources from the sea and reduce market impediments to future industry growth (Federal Register, 1973). In public response to this NMFS proposal, consumers across the nation overwhelmingly agreed (Federal Register, 1974; USDC, 1974a). This current research study by the NMFS may place the market name as the official common or usual name for future labeling consideration.

Materials and Methods

The Commerce Department's National Marine Fisheries Service (NMFS) proposed to organize and clarify existing nomenclature and provide a system for the establishment or changing of nomenclature (Federal Register, 1974) by:

1) Developing a basic set of principles for product identification.

2) Constructing and evaluating a model system.

3) Designating a format for presenting names in an organized manner.

4) Preparing procedural and implementing plans to make a system operational.

A feasibility study was conducted by the Brand Group, Inc.[6], a consulting organization specializing in planning, design, and marketing, under U.S. Government Contract 4-36730 (USDC, 1974b). To understand the scope of the problem required a comprehensive look at the industry, its structure, marketing practices, the consumer, and the regulatory environment. Exploratory interviews were conducted by the contractor with NMFS and FDA personnel, industry representatives, scientists, and consumers. Survey questionnaires, bibliographic searches, past regulatory decisions and focus group sessions were used to gather a preliminary base of information.

The research suggested that efficient sorting of this mass of information involved development of a comprehensive

[6]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Product Form Definitions

Whole fish: Fish as captured, ungutted.

Headed: Fish from which the heads have been cut or broken off.

Drawn: Marketed with only the entrails removed.

Drawn and headed: Drawn fish from which the heads have been cut or broken off.

Dressed: Drawn and headed fish with scales, fins, and tails removed.

Fillets: Strips of flesh cut parallel to the central bone of the fish and from which fins, main bones and sometimes belly flap have been removed; presented with or without skin.

Butterfly fillets: Flesh cut from both sides of the same fish, the two pieces remaining joined together along the belly or back.

Fillet sticks: Uniform rectangular sticks of fish cut from frozen white fish fillets.

Fillet portions: A piece of fillet cut to reasonable size for the individual for retail sale.

Steaks: Cross-section slices from large, dressed fish.

Steak portions: A piece of steak cut to a reasonable size for the individual for retail sale.

Chunks: Cross-section of large, dressed fish either including a cross-section of the backbone or cut to convenient sized pieces.

Flakes: Cross-section of large, dressed fish cut into smaller pieces than the chunk style.

Minced: Minced, shredded, or grated flesh of uniform size and texture.

Paste: Fish flesh ground to a fine consistency.

Servings: Rectangular "portions" formed to convenient individual sized pieces, formed from fillet blocks or minced flesh.

Sticks: Term used alone designates fish sticks made from either fillet blocks or minced flesh.

Figure 9.—Standardized definitions of product forms.

	Made from one fish	Made from similar group	Made from mixed group
Fresh	Red snapper		
	Fillets		
	Fresh		
Frozen	Rainbow trout	Shrimp	Ocean fish
	Butterfly fillets	Sticks	Sticks
	IQF	Breaded and cooked	Breaded and cooked
Canned	Brisling sardines	Codfish	Shellfish
	Fillets	Dumplings	Bisque
	Packed in oil—salt added	With potatoes and peas	In heavy broth
Cured	Atlantic cod	Tuna	Seafood
	Steaks	Sausage	Wieners
	Smoked		
Dehyd.	Bigeye scad	Whitefish	Fish
	Gutted and headed	Meal	Flour
	Sun dried		

Figure 10.—Examples of product identification.

factor list. Figures 7 and 8 indicate the complex nature of dealing with all but three of those factors: Color, texture, and bones, respectively. A computer program was developed to assist in the organization of similarities among these large numbers of independent bits of information. The sorting had to become automatic and objective. Factor list questions were derived from the interviews conducted as mentioned earlier and these results were incorporated into a fish/factor matrix for further analysis (Fig. 4). To relate these factors to the list of fish, many individuals experienced in the seafood industry were interviewed and an experimental matrix of 43 factors and 122 fish easily fell into natural groupings when related to the matrix criteria; other fish judged by the same set of factors were more difficult to distinguish. By more careful factor analysis, however, they too could be sorted effectively. These early results indicated that the factor list had to be more carefully analyzed, delineated, and weighted for relative importance.

A set of 12 base terms was established for the "form" that identifies most seafood products: Whole, headed, drawn, dressed, fillet, steak, chunks, flakes, minced, paste, servings, and sticks. A basic standardized definition list was developed (Fig. 9) and applied schematically (Fig. 10). All this information is essential; any more would probably be unnecessary in the product name while any less would leave out important data.

This research also extracted from relevant reference sources (International Congress of Zoology, 1964; OECD, 1968; Jordan and Evermann, 1969; USDC, 1978a; Robins et al., 1980) all that could be found on the: 1) Common name; 2) alternate common name; 3) common name reference sources; 4) common name historical data; 5) common name geographic usage; 6) common name dates of origin and use; 7) scientific name; 8) scientific name reference sources; and 9) scientific name modifiers. The data was stored in computer banks for easy cross reference, additions, deletions, and a variety of other useful search and sort operations. Since no single comprehensive list of useful names exists at present, these data may speed the future development of an official list of common names.

The conclusions from this exploratory phase of the research indicated that:

1) A comprehensive factor list was possible to develop, but had to be further refined; 2) a matrix had to be developed to relate the factors to food fish and establish tentative standards of comparison; 3) a procedure had to be established for automatic sorting of food fish into groupings; and 4) a structure had to be developed to administer, maintain, police, and operate the proposed nomenclature program (Anonymous, 1975a).

A prototype identification plan could be developed from this data base and a system designed to assure proper nomenclature responses for the future. This proposed reorganization of common names would provide direction for improving the problem at a phased-in pace, reduce the burden of dealing with so many names and develop a framework for administrative decision making (Anonymous, 1975a, b).

Upon acceptance of this feasibility study, the National Marine Fisheries Service moved into phase I of a long range program to put into place a system to 1) develop a data bank related to the edible characteristics of seafood species; 2) analyze the data bank to determine species that have similar characteristics; 3) develop a model identification plan that is based on communicating edible characteristics; and 4) review the model plan with an independent panel of experts to identify ways to implement the plan most effectively, under U.S. contract 6-35338 (USDC, 1978b).

In December of 1976, a factor list mail survey questionnaire was sent to user groups to better identify the edible characteristics of commercial aquatic species. A typical page from this part of the research is shown in Figure 11. Instructions to recipients stated "our primary concern is with characteristics that are natural to the species (such as taste, texture, etc.) and with outside factors that may affect these characteristics. In addition, we are concerned with how aquatic species are processed, purchased, and prepared. We are trying to look at these characteristics and factors from the viewpoint of the consumer. In this study, we are not interested in such things as price and value, but rather in factors that are natural and predictable, and have to do with their edibility" (Anonymous, 1976).

The specific research objectives were to: 1) Identify those species most important to a model retail identification plan; 2) identify those edible characteristics factors that are significant; 3) determine the priorities and relative importance of these factors; and 4) develop a model based on key factors to demonstrate how effective species identification can be accomplished.

The survey questionnaire (page example, Fig. 11) was mailed to 760 prospects who represented a cross-section of the seafood industry, Federal and state agencies, educational institutions, and appropriate miscellaneous groups. The 159 completed and returned questionnaires constituted the first analytical phase of the study.

Factors were rated by respondents on a 5 (very important) to 0 (not important at all) scale. The questionnaire also obtained a list of species that were commercially relevant and a commitment by a respondent to rate those he was most familiar with, relative to edibility characteristics, on future surveys. Data were collected and computerized for mean rating of factors and priority ranking of species.

The original determination of potential edible characteristics that should be profiled was developed under contract 4-36730 (USDC, 1974b). The objective of this next phase of the research was to qualify those factors and expand them if enough members of the survey so indicated.

It was determined that the criteria for including a species in further research would be 1) a minimum of 10 percent of the respondents stating that it should be included and 2) a minimum of five respondents stating that they could rate the species for their edible characteristics.

Out of an initial listing of 187 species, 153 met both the characteristics and factors that were common and/or specific to finfish and shellfish, and which could be grouped into major categories. Respondents were also asked to add other characteristics and factors under each category. The initial findings are presented in Table 1. A detailed analysis of the responses was made to assess the inclusion and/or deletion of factors based on frequency of response. It was determined that a majority of the factors added by respondents fell into two categories:

1) They were redundant, i.e., the same as or similar to factors originally listed on the questionnaire.

2) They were not characteristics of the species, and therefore would not fit into the profile.

The significance of the original list of factors selected for inclusion in the questionnaire is demonstrated by the attention given to their ratings by respondents, i.e., 1) of the 159 respondents who rated any factor, 152 (95 percent) rated over 70 percent of the original list of factors; 2) 137 respondents (86 percent) rated 100 percent of the original list; and 3) no more than 12 respondents (8 percent) rated any single write-in factor.

Respondents rated 40 original edibility factors on a 5 (very important) to 0 (not important at all) scale. The remaining factors, including those that respondents wrote in, were then subjected to an analysis of the "importance" ratings

Table 1.—Number of species initially on questionnaire and the number added by respondents.

Factor category	No. of species originally on questionnaire	No. of species added by respondents	Total[1]
External characteristics of the species (i.e., anatomical)	10	83	93
Internal characteristics of the species	16	48	64
Environmental factors that affect edible characteristics	7	38	45
Processing factors: Conditions imposed by industry processing	3	47	50
Preparation factors: Related to consumer purchase, preparation, and serving	4	23	27
	40	239	279

[1]Totals include factors that are specific to finfish and shellfish and factors that are common to both.

Please rate each of the following items using the scales for both finfish and shellfish.

You may ask yourself, "How important is each item in terms of purchasing, preparing or eating finfish or shellfish?"

Please indicate your opinion by circling one number on each scale. If you wish to express no opinion, circle "X".

Please use these ratings for finfish								**Please use these ratings for shellfish**						
Very important					**Not important at all**	**No opinion**		**Very important**					**Not important at all**	**No opinion**
5	4	3	2	1	0	X_8	EXTERNAL CHARACTERISTICS OF THE SPECIES	5	4	3	2	1	0	X_{16}
5	4	3	2	1	0	X_9	Color and markings on the body	5	4	3	2	1	0	X_{17}
5	4	3	2	1	0	X_{10}	General body shape (i.e., shapes of eel vs. flounder vs. sea bass vs. lobster)	5	4	3	2	1	0	X_{18}
5	4	3	2	1	0	X_{11}	Characteristic anatomical features (i.e., barbels, fins, type of jaw, etc.)	5	4	3	2	1	0	X_{19}
5	4	3	2	1	0	X_{12}	Overall average size of the species	5	4	3	2	1	0	X_{20}
5	4	3	2	1	0	X_{13}	Size of the scales on the species (when marketed whole)	Not applicable						
5	4	3	2	1	0	X_{14}	Number of the scales on the species (when marketed whole)	Not applicable						
5	4	3	2	1	0	X_{15}	How difficult it is to remove scales from the species (when marketed whole)	Not applicable						
Not applicable							Configuration of the shell of the species (when marketed in the shell)	5	4	3	2	1	0	X_{21}

Figure 11.—Page example of survey questionnaire.

OMB Approval
#41-S77048
Expires December, 1978
BF#1606

Edibility Profile for Commercial Aquatic Species

1606
1-4
5-7

Please check one.
finfish ☐ shellfish ☐ other ☐

Please fill in the common name and scientific name of the species you are rating on this form. Include any alternative names in common use.

Common Name ____________________

Alternate Common Names ____________________

____

Scientific Name ____________________

Alternate Scientific Names ____________________

____

In the following sections, please check the box in each row that most represents the characteristics of this species. ☐☐☐ 8 9 10

1 Characteristics of the Meat

In this section we are interested in the characteristic edible qualities of the meat of individual species of finfish and shellfish. Assume the meat is fresh and clean; that it has been properly handled and prepared; and, in evaluating the flavor, only consider the natural flavor of the species and not of any sauces or seasonings that may be used in the preparation.

CHARACTERISTIC FLAVOR AND TEXTURE OF THE MEAT

Flavor of the meat (intensity)	mild	☐☐☐☐☐	strong	11
Flavor of the meat	not unique & distinctive	☐☐☐☐☐	unique & distinctive	12
Flavor of the meat	not sweet	☐☐☐☐☐	sweet	13
Flavor of the meat	not sharp	☐☐☐☐☐	sharp	14
Flavor of the meat	not salty	☐☐☐☐☐	salty	15
Texture of the meat	mushy	☐☐☐☐☐	firm	16
Texture of the meat	not flakey	☐☐☐☐☐	flakey	17
Texture of the meat	smooth	☐☐☐☐☐	coarse	18
Moisture content	dry	☐☐☐☐☐	moist	19
Fat content	not fatty	☐☐☐☐☐	fatty	20

CHARACTERISTIC ODOR OF THE MEAT

Characteristic odor before cooking	mild	☐☐☐☐☐	strong	21
Characteristic odor after cooking	mild	☐☐☐☐☐	strong	22
Characteristic odor before cooking	not unique & distinctive	☐☐☐☐☐	unique & distinctive	23
Characteristic odor after cooking	not unique & distinctive	☐☐☐☐☐	unique & distinctive	24
Tendency to smell "fishy" before cooking	not "fishy"	☐☐☐☐☐	very "fishy"	25
Tendency to smell "fishy" after cooking	not "fishy"	☐☐☐☐☐	very "fishy"	26

CHARACTERISTIC COLOR OF THE MEAT

Color of the meat before cooking	white	☐☐☐☐☐	brown or grey	27
		or		
	pinkish	☐☐☐☐☐	red	28
Color of the meat after cooking	white	☐☐☐☐☐	brown or grey	29
		or		
	pinkish	☐☐☐☐☐	red	30
Shade of the meat before cooking	light	☐☐☐☐☐	dark	31
Shade of the meat after cooking	light	☐☐☐☐☐	dark	32
Uniformity of the color	uniform	☐☐☐☐☐	mottled, veined, etc.	33

OVERALL QUALITY

Overall quality of the meat	poor	☐☐☐☐☐	excellent	34
Overall quality of the flavor	poor	☐☐☐☐☐	excellent	35
Overall quality of the texture	poor	☐☐☐☐☐	excellent	36
Overall quality of the odor	poor	☐☐☐☐☐	excellent	37

Figure 12.—Page example of individual species rating questionnaire.

Table 2.—Major survey findings for finfish.

Factor category	Number of factors in each range of importance ratings 1.00-1.99	2.00-2.99	3.00-3.99	4.00-5.00
External (physical appearance)	2	3	2	
Eating characteristics			9	7
Environmental (effects on edibility)	1	5	1	
Processing			3	
Preparing (serving by consumer)		1	3	

Table 3.—Major findings for shellfish.

Factor category	Number of factors in each range of importance ratings 1.00-1.99	2.00-2.99	3.00-3.99	4.00-5.00
External	1	3	3	
Internal		1	6	4
Environmental	1	4	1	1
Processing			2	
Preparing		1	3	

given to them by respondents. The purpose here was to establish a ranking of factors and/or categories relative to profiling edible characteristics. The major findings for finfish are given in Table 2 and the primary findings for shellfish are listed in Table 3.

Research among seafood specialists and consumers indicates that the following are the most important factors: 1) Intensity of flavor, 2) flakiness of the meat (after cooking), 3) fat content, 4) firmness of the meat (after cooking), 5) natural odor of the meat when raw and fresh, 6) coarseness of the meat, 7) color of the meat (after cooking), and 8) moistness of the meat (after cooking).

These findings make it obvious that the seafood industry considers the "consumer-related" factors of organoleptic characteristics (i. e., the nature of the meat of the species) and preparing and serving considerations the most important in compiling a profile of individual species as the basis for comparison, and as the basis for a potential identification system.

These data reinforced the findings of additional qualitative focus group research conducted with consumers, which revealed that internal characteristics and preparation factors were their most important concerns also.

As a result, the number of factors in the second industry mail survey were reduced from 55 to 8. Flavor, fat content (after cooking), odor, color, flakiness, moisture, firmness, and coarseness were considered to represent the most perceptible differences, and to offer the most fundamental information to the consumer.

In summary, this phase of the research filled in gaps relative to species and characteristics for further study, and prioritized critical areas for more effective structuring of a meaningful edibility profile.

The next mail survey carried us to the respondents who indicated that they would be willing to individually rate certain species based on each of the selected factors. The second study (Fig. 12) (Anonymous, 1977), was based on 297 species and 870 questionnaires completed by 245 respondents. The objective was to gather data from 3-5 different respondents for each species and determine a mean rating for each factor to use for sorting studies.

A visual profile (Fig. 13) has been developed for each of the 158 species rated in the study. This graphic representation could also be used in future consumer education programs (USDC, 1978b).

Edibility profiles provide a consistent basis for comparing the edible characteristics of the sample species. In addition, they provide a great deal of useful information to consumers. Knowing the edibility profile for a fish can reduce the fear of trying new and unfamiliar seafood species and products. This is information that is not currently available for selecting edible species.

The edibility profiles were then compared to determine which species had similar patterns of edible characteristics so a determination could be made on an objective method of organizing species into distinct groups. Seven studies, using computer analysis, were conducted to determine this grouping.

Edibility characteristics for shellfish were included in some of the early studies. This helped to confirm that, although shellfish and finfish can be com-

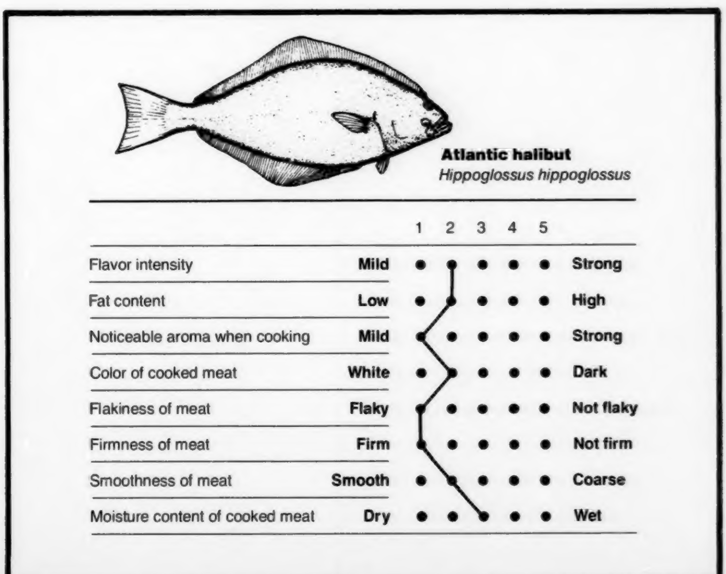

Figure 13.—A typical edibility profile.

pared on some factors, each represents a different kind of eating experience and should be classified separately. Later studies were confined to finfish.

In earlier studies, various combinations of up to 40 factors were tried. In later studies, edibility profiles based on eight factors and a 5-point rating scale were determined to be a more convenient, effective basis of comparison for the 123 species of finfish used in the model.

Different factor-weighting strategies were explored in the analysis. In one set of studies, all factors were weighted equally. In others, various priorities of factors were tried. Based on these studies, the following observations were made:

1) Changes in weighting strategies affected the clarity of groupings without producing serious changes in the placement of species in groups.

2) Changes in the number of species used affected where fish were placed as relationships became available or were removed.

3) Excluding anatomical features (i.e., bones, body shape, etc.) from early studies caused almost all correlations with zoological groupings to disappear.

4) Reduction of the number of factors from 40 to 8 produced greater clarity without radically affecting the general groupings produced by the factors.

5) A wide variety of edible profile patterns exist among species when they are compared on the basis of multiple (8) equally weighted factors. This results in a great number of small groups being formed, each of which has a different profile for the eight factors.

6) Strong weighting of certain factors resulted in fish being sorted into groups that were similar to groups formed on the basis of equally weighted factors, but which were easier to adapt to a simple organizational framework.

In the final studies, these eight factors were given a geometric progression of weights in the following order: Flavor, 8; Flakiness, 8; Fat, 4; Firmness, 4; Odor, 2; Moistness, 2; Color, 1; Coarseness, 1.

With this assigned geometric progression of weights, sets were divided along lines established by the first two (highest weighted) factors: Flavor and Flakiness. Subgroups were determined by each subsequent pair of factors, according to the weighting assigned.

These studies showed that establishing factor priorities is a necessity. The factor sorting approach produced results that are far easier to communicate to consumers. In addition, by using this approach, species can be classified without the need for computer processes.

A framework now had to be built around the data that had been accumulated so it could be handled effectively. To develop an identification system that included all eight factors and a 5-point rating scale would require an array of almost 400,000 separate groups. A more practical approach led to a selection of a pair of key factors as a primary basis for determining groups of similar species. A pair of factors based on a five-point rating system provided a framework with 25 manageable groups. Two factors are adequate at the similar species level (Tier II) for product identification and two factors can be communicated in simple visual diagrams. This is extremely important in communicating with consumers through pamphlets, handbooks, and posters which will help explain the product identification system.

Figure 14 describes the framework developed for the Tier II level. It is based on "Comparative Edibility." Each block represents a category of finfish that are

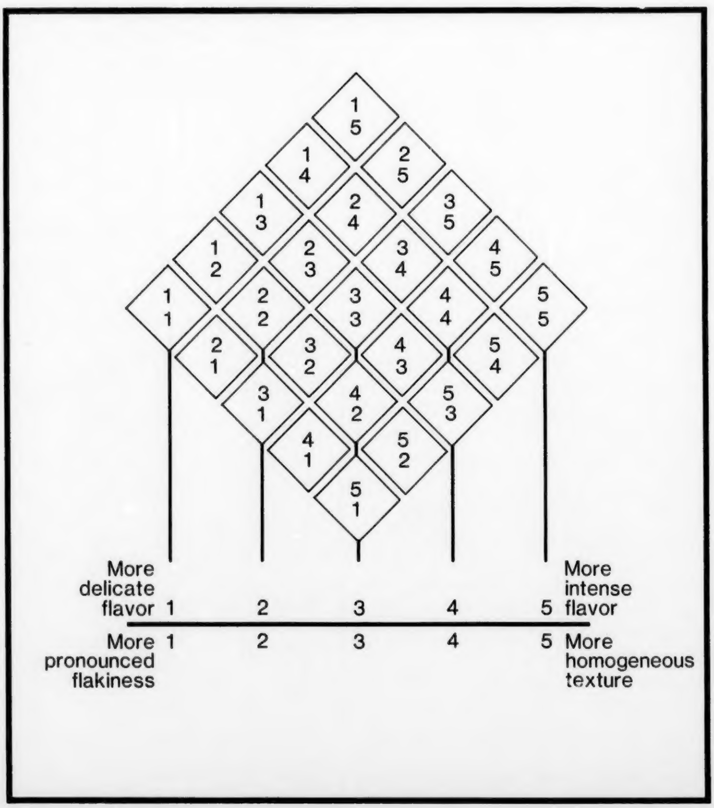

Figure 14.—Edibility framework for finfish based on two most important factors.

similar for two key factors. The numbers in each block represent the ratings for the pair of factors. All finfish species that have identical ratings for the pair of factors will be located in the same block. One block is provided for each combination, whether or not there are any commercially marketed fish that have the combination of characteristics. Thus, a place is maintained for future classification of any species which is not now marketed.

The blocks and the framework are arranged along a horizontal line, drawn from left to right and having a range from 1 to 5. The blocks are arranged so that the values for both factors rise when reading from left to right. When reading from top to bottom or bottom to top, the value of one factor drops while the other rises. Vertically, the sum of the values are equal. The three blocks having the values of 5/3, 4/4, and 3/5 each add up to a value of 8, but remain distinct from one another in the framework. This provides a scale which, reading from left to right, progresses evenly from one extreme of the rating scale (1/1) to the other (5/5).

Using this framework, all fish can be classified into the 25 primary groups by the following method:

1) Two edibility factors are chosen as the basis for comparison.

2) For each fish, a standard rating is determined on a scale from 1 to 5 for each of the two factors.

3) On the basis of these ratings, the fish is assigned to the appropriate group.

Flexibility has also been included in this system that will allow subcategorization within any block if it should become overburdened with a large number of fish. Each of the 25 groups can be "magnified" independently to include an additional pair of edibility factors which would yield as many as 25 additional subgroups and thus further refine the sorting process.

As in all organizations of this type, some priorities must be established and a determination made as to which pair of factors will be considered primary. Consumers and industry provided the following factor priorities derived from the focus groups and questionnaires.

(1) First Priority Factors
Flavor
Flakiness

(2) Second Priority Factors
Fat
Firmness

(3) Third Priority Factors
Odor
Coarseness

(4) Fourth Priority Factors
Color
Moisture

Trial runs at this point in the program yielded the following observations: 1) There are a great variety of edible profiles, 2) there is no direct correlation with zoological categories, 3) there is little relationship between edibility factors, and 4) the majority of species consumed in the United States tend to cluster around the mild and flaky area of the design. Only a few are near the extremes of strong tasting and nonflaky meat.

To gain broader acceptance and review of the research effort to this point, the NMFS published in the Federal Register (Federal Register, 1978; Anonymous, 1978b) the availability of the Model Retail Identification Plan for public comment. NMFS asked the following six basic questions:

1) Is the model identification plan a logical approach for the construction of a complete identification system for finfish and products therefrom?

2) Are the edibility factors (8) identified in the model plan the most significant and useful in determining product edibility? Are they too numerous or too few? And are they listed in the appropriate order or priority?

3) Should objective methods be used to measure the edibility factors quantitatively?

4) Should NMFS proceed to develop fully and implement a new seafood identification system, based upon a comprehensive data bank of edibility characteristics for a seafood species?

5) Should NMFS develop guidelines and procedures for interim changes in existing nomenclature?

6) Should NMFS develop interim marketing directions?

More than 1,000 requests were received for the study and 80 percent of the public response enthusiastically supported the effort and urged continuation of the research (Brooker, 1979). International support was also received through the Food and Agriculture Organization (FAO) of the United Nations (Krone[7]).

The Food and Drug Administration, in their response to the Federal Register release, still maintained "serious reservations" about the nomenclature system (Anonymous, 1978c; Randolph[8]). The news media was quick to pick up this unique development also (Kramer, 1978a,b,c; Steinman, 1978; Gordon, 1979; Heurdejs, 1979; Miller, 1980a,b). The importance of the program was also emphasized by the Department of Commerce's National Oceanic and Atmospheric Administration when, in a policy and program statement, it said "NOAA will accelerate and complete its work on fish nomenclature to assist the industry and the U.S. consumer. When completed, this work will provide comprehensive information on the edibility characteristics of fish, particularly nontraditional species, so that distributors and consumers can make better use of available fish protein from U.S. domestic fishing efforts" (Anonymous, 1979b).

Responding to question three from public comment concerning the need for objective methods to measure the edibility factors quantitatively, the NMFS awarded a research contract (No. 01-8-M01-6320, January 1979) to Natick Laboratories, Natick, Mass. The objectives of this project were to 1) develop and evaluate standardized subjective and objective methods for assessing the edibility of fish products and 2) evaluate a correspondence between instrumental and sensory indices of edibility so that

[7]Krone, W. 1978. Model retail identification plan for seafood species. FD 52/1.1. FAO, Rome, Italy. Pers. commun.

[8]Randolph, W. F., 1978. Department of Health, Service, U.S. Food and Drug Administration, Rockville, Md. Pers. commun.

TEXTURE PROFILE BALLOT FOR FIN FISH

DATE: ____________

PANELIST: ____________

SAMPLES

		A	B	C	D	E
FIRST BITE	Hardness					
	Flakiness (tongue against palate)					
MASTICATION	Chewiness					
	Fibrousness					
	Moistness					
	Cohesiveness of mass (at 10 chews)					
	Adhesiveness					
RESIDUALS	Oily mouthcoating					
	Astringent-like mouthcoating					
COLOR	Lightness: Skin side					
	Skeleton side					
	Uniformity of lightness: Skin side					
	Skeleton side					

Figure 15.—Texture profile ballot for finfish.

fish species can be grouped according to their similarities.

The sensory methods included an expert flavor profile panel, a texture profile panel, and consumer panels. The objective methods included Instron (texture) and gas chromatography-mass spectrometry (flavor) measurements. Sensory scaling data were obtained using the method of magnitude estimation. These data were submitted to multidimensional scaling analysis. Advantages of these techniques are: 1) They do not require a specific reference species, 2) they provide ratio data for comparison with objective measure, 3) they result in data that can be summarized in a graphical format, and 4) the magnitude of similarity or difference between species can be statistically tested (King et al., 1979).

For each species selected, analysis was based on fish in the fresh state (ice chilled for 48 hours after harvest). Cooked fish samples were evaluated based on procedure 18.0036 of the Association of Official Analytical Chemists (boil-in-bag) (AOAC, 1980). Cooking time periods for the various thicknesses of fish were established from heat penetration measurements in order to cook all samples uniformly and provide reproducibility from batch to batch. Both trained and consumer panels were used for sensory evaluation. Sensory evaluation of texture (Fig. 15) was based on the General Foods Texture profile method (Civille and Liska, 1975; Civille and Szczesniak, 1973).

Instrumental texture measurements were based on an Instron tester using uniaxial compression to 60 percent of the fish sample's original thickness (Johnson et al., 1980b).

To compensate for lack of parallelism and surface flatness, because the boil-in-bag method distorts the fillets to a point where no suitable flat surface can be found, a swivel-head compression plate was mounted on the moving cross-head of the Instron. Samples could then be easily cut into uniform cylinders and tested (Johnson et al., 1980a,c).

As a result instrumental and sensory methodology has been developed for the objective measurement of the edibility characteristics of finfish and applied to the grouping of underutilized species

according to their similarities in edibility characteristics. This quantitative data fine tunes the analysis that preceded the beginning of this study.

Studies of four instrumental methods for measuring texture, using compression, shear, and tension, resulted in the development of a rapid, simple procedure.

Through a unique application of the descriptive/analytic technique of texture and flavor profile analysis, combined with consumer methods of sensory evaluation, a method for evaluating the "edibility characteristics" of fish has been established. This comprehensive approach permits the evaluation of subtle, but important, textural and flavor differences over a wide range of species, using terminology that can be easily understood by consumers and which provides a basis for direct comparison of similarities and dissimilarities among species.

Using this method a data bank of sensory profiles for 17 species of fish was established. An analysis of various techniques of grouping fish was conducted, and a method based on multivariate cluster analysis was found to be both internally consistent and reliable for establishing similar and dissimilar groups. Three major edibility groups and several subgroups were identified. The results are contained in a 620-page report, referenced below.

Analytical determinations have been made on a variety of finfish fat content, color, moisture, and fatty acid composition. These data, in conjunction with sensory panel investigation of the same species indicate that fish are amenable to classification (Kapsalis and Maller, 1980).

During this same period, another unique test of the developing nomenclature scheme was begun. Anthony's Seafood Grotto Restaurant, San Diego, Calif., began developing prototype menus using edibility profiles to introduce customers to new products or unfamiliar seafood selections (Anonymous, 1979c). Early results of this project show good patron acceptance and understanding of a visual means of presenting edibility profiles.

To complete the conceptual framework of the nomenclature system, Contract NA-79SAC-00804 was issued to the Chicago-based brand identification and design consulting group, for an analysis of the "Forms" and "Modifiers" portion of the program (USDC, 1979a). This search produced a list of nearly 600 terms used in various ways in the seafood industry. These terms were then organized alphabetically, and grouped according to similarity with a dictionary-type index that provides definitions and explanations for the terms. Analysis of this bulk of information yielded the following observations (USDC, 1981):

1) There was too much semantic noise presently in the marketplace.

2) There was, on occasion, too many terms for one concept (i.e., eight different ways to say "fish with the head removed").

3) A single term that was being used in several unassociated ways.

4) Terms that have more than one spelling or structure.

5) Terms that had no clear meaning.

6) Terms where the position of words affected the meaning.

7) Terms used elsewhere in the food industry in one context, but which in the seafood industry carry a different meaning.

This basic text could be developed as one more tool to help educate consumers when the program is ready for implementation.

Results and Discussion

A major research effort has been successfully completed that lays down a scientifically sound basis for constructing a practical and effective nomenclature system for communicating highly organized information about seafoods in simple ways to users of fishery products through market names and labeling. The information to be used in constructing seafood product names is derived from qualitative and quantitive laboratory analysis of the edibility characteristics of the fish flesh, coupled with other essential information about the physical form of the product itself, how it is preserved, and the presence of other food ingredients that characterize the end product.

The results of the quantitative research phase provided information from which a "Manual of Test Methods and Procedures" has been prepared which lays down official laboratory procedures for testing fish and generating edibility data in a consistent uniform manner. It also identifies the characteristics to be tested and recommended scales for quantifying the data (USDC, 1983).

Other research results provide specific recommendations for constructing nomenclature pertaining to seafood product forms and modifiers which are major components of the seafood identity system (USDC, 1981).

This brings to a conclusion the entire research phase essential to the development of a practical and effective seafood identification system.

Future developments must address the following steps to put the new seafood identification system into place and use:

1) Develop an edibility data bank of major foods species using the established analytical methods and following an established testing protocol.

2) Develop a data management system and control documents to assure that only reliable high-quality data are used.

3) Develop a model format for communicating to users about the edibility characteristics of individual species.

4) Formalize the seafood identification system for introduction, and a management plan for its continued use and maintenance.

5) Educate consumers and all segments of the industry by publishing both a comprehensive Consumer Shopping Guide and an Industry/Retail Identification Standards Manual.

6) Implement the system nationally.

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Economic Potential for Utilizing Minced Fish in Cooked Sausage Products

RICHARD J. AGNELLO

Introduction

The Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265) and the American Fisheries Promotion Act of 1980 (P.L. 96-561) combined to establish the legal basis for the conservation and management of most fishery resources within the U.S. Fishery Conservation Zone (FCZ) and in some cases beyond the FCZ to the end of the U.S. continental shelf. The Acts also provide the opportunity for expanding the U.S. fishing industry especially in cases where foreign catch within the U.S. FCZ has been large. Unless domestic markets can be found, however, it is likely that the United States will continue to allocate large quantities of underutilized species to foreign countries for the foreseeable future.

P.L. 94-265 and P.L. 96-561 (together herein referred to as MFCMA) provide a framework for defining and allocating the Total Allowable Level of Foreign Fishing (TALFF). The MFCMA also determines that charges to foreigners for harvesting the resource be at least equal to management and enforcement costs incurred by the United States. Charges imposed on foreigners have included fees for permits, poundage caught, foreign surcharges, and on-board observation. Permit and observer fees reflect administrative costs and are independent of resource value. Since poundage fees reflect a percentage (3.5, 7, or 10 percent) of dockside (or ex-vessel) price of fish actually caught by foreign vessels, these are related to resource valuation. A surcharge when imposed adds a fixed percentage (20 percent in 1981) to poundage and permit fees. Even in the case of poundage fees, it is not clear whether the fee is closely related to the value of the fish resource to foreigners. Since the poundage fee does not systematically vary according to willingness to pay by foreign harvesters, the fee for a particular species may be below foreign valuations.

Several studies support this view. Meuriot and Gates (1982) reviewed the literature as well as provided evidence that long-run net benefits to foreigners for walleye pollock, *Theragra chalcogramma*, varied from \$38 to \$117 million per year (1979 dollars). In contrast, poundage fees for walleye pollock for 1981 totaled less than \$21 million (or \$0.76 per pound) based on a poundage fee of \$14 per metric ton plus a 20 percent surcharge[1].

In response to incentives created by the MFCMA, Government policies supportive of U.S. industry expansion appear likely. Indeed, studies have been undertaken by the National Marine Fisheries Service to investigate future development possibilities (e.g., Combs, 1978, 1979).

This paper investigates the economic potential of one such policy: Namely the utilization of up to 15 percent minced fish in the production of hot dogs and other cooked sausage products. Since the U.S. Department of Agriculture (USDA) establishes identity standards for hot dogs, the potential utilization of minced fish in products labeled hot dogs would require USDA approval. Some economic background relevant to the assessment of the utilization of minced fish in hot dogs is presented in this paper. Economic factors investigated include the potential market, costs, competitiveness of minced fish, and potential economic impacts.

The meat-bone separation technology provides an opportunity for domestic utilization of some species which are often too small to fillet (e.g., walleye pollock; silver hake, *Merluccius bilinearis*; and red hake, *Urophycis chuss*). In addition, the meat-bone separation technology enables recovery of high quality fish flesh from larger fish whose fillets have been removed in a traditional manner. These species include most Atlantic cod, *Gadus morhua*; large silver hake, and large walleye pollock.

Research and development has been done on the utilization of the meat-bone separation technology for fish (e.g.,

ABSTRACT—In this paper the economic feasibility of using up to 15 percent minced fish flesh in cooked sausage products is investigated. The cost structures for harvesting and processing walleye pollock and silver hake are examined in detail using alternative modes of production, accounting procedures, and assumptions. For walleye pollock, a catcher/processor operation has the lowest cost structure. Minced fish appears to be price competitive with the middle to upper range of ingredients in frankfurters. Since the nutritional aspects of minced fish are equal or superior to current frankfurter ingredients, a strong potential market appears to exist, although limited in size. The potential market for minced fish will not be large relative to either the cooked sausage market or the allowable level of foreign fishing (perhaps 10 percent in each case). Thus the impacts on both the U.S. fishing and agricultural sectors appear small.

[1]Fred Olson, Economist, National Marine Fisheries Service, NOAA, Washington, DC 20235. Pers. commun.

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Torry Fish Research Station, 1976). Although technically feasible for a variety of products including cooked sausage, little commercial application has occurred in the United States. In Japan, however, large-scale commercial use of walleye pollock for processing into surimi (a stabilized and frozen fish paste that is made from minced fish) has taken place over the last 10 years.

Potential for Minced Fish

The 1981 TALFF for walleye pollock, Atlantic cod, silver hake, and red hake totaled 1.25 million metric tons (2.76 billion pounds, round or liveweight basis). The TALFF, in accordance with the MFCMA, excludes amounts allocated for domestic fishermen, either for landing in U.S. ports or for at-sea transfer to foreign-flag vessels for processing and transport to foreign countries. The TALFF is consequently smaller than the optimum yield and the maximum sustainable yield, as determined in accord with the MFCMA. Table 1 presents the real and potential catch of the selected species and especially shows the low domestic utilization of walleye pollock. One can clearly see that the potential of these underutilized species is quite large relative to all U.S. landings. In 1981, the TALFF for walleye pollock alone amounted to 45 percent of all U.S. landings.

Assuming yields of 30-50 percent of the liveweight of fish, one obtains a potential minced fish output of 0.8-1.4 billion pounds for the 1981 TALFF (where 2,205 pounds equals 1 metric ton). Production of mince from larger fish now harvested and processed into fillets by U.S. firms would be quite small by comparison although potentially important for the firms involved. Assuming a 10 percent yield for Atlantic cod with fillets removed, and using average landings of 43,575 metric tons from Table 1, around 10 million pounds of Atlantic cod mince would be available.

Nature of the U.S. Sausage Market

The U.S. sausage market, excluding poultry items, amounted to about 5.04 billion pounds in 1981—almost twice the size of the U.S. market for fish. Of this, 2.18 billion pounds were cooked sausage in the form of hot dogs, frankfurters, weiners (1.42 billion pounds), and bologna (0.76 billion pounds) (American Meat Institute, 1982).

The amount of minced fish potentially available from harvesting and processing the TALFF is quite large relative to possible use in the production of franks and other cooked sausage products. The amount of minced fish would clearly be in excess of possible demand in all cooked sausage products, even in the unlikely event that all such sausages contained 15 percent minced fish (requiring approximately 0.33 billion pounds of minced fish). At 5, 10, and 15 percent rates of inclusion in meat franks only (perhaps 0.9 billion pounds excluding beef and poultry franks), use of minced fish flesh would be 45, 90, and 135 million pounds. These magnitudes represent only a fraction of the 0.8-1.4 billion pounds of minced fish potentially available.

Meat franks and weiners are the leading item in the hot dog segment of the sausage market based on special survey data for retail sales (sales for at-home consumption only) conducted by the USDA (Sun, 1982). The breakdown was: Beef, 52 million pounds; poultry, 11 million pounds; and meat, 87 million pounds (average retail sales for 2-month periods during June 1977-November 1980). On a percentage basis, retail sales for the frank and weiner categories of beef, poultry, and meat were 34.7, 7.3, and 58.0 percent, respectively.

The total market for sausage is forecast to continue growing at an annual rate of 1 percent through 1987. However, the weiner and frank segment may continue to decline at a rate of 0.5 percent because of adverse publicity created by the nitrite issue (American Can Co., 1982).

Prices for the various types of hot dogs and sausage ingredients vary significantly. Average retail prices in 1980 were $1.84, $1.11, and $1.58 for beef, poultry, and meat hot dogs, respectively, derived from Sun (1982) and the Consumer Price Index (CPI) for food items (USDL, 1982). At the wholesale level, the most common ingredients in hot dogs vary in price from $0.25 to $0.35 a pound for mechanically deboned chicken to over $1.00 per pound for lean beef. Table 2 presents the current wholesale price structure for common hot dog ingredients.

Costs for Fish Flesh

Current production costs for fish flesh are derived from profit and loss statements found in Combs (1979). This report presents costs for seven underutilized species including two species for consideration in cooked sausage, namely walleye pollock and silver hake. For Atlantic cod and red hake, both Atlantic species, costs similar to those of

Table 1.—Actual and potential catch of selected gadids from resources within U.S. jurisdiction, with comparisons (metric tons, liveweight basis)[1].

Species and area of catch	Optimum yield	TALFF 11/1/80 to 12/31/81	U.S. landings (1977-81 avg.)
Pacific			
Walleye pollock			
Eastern Bering Sea & Aleutians	1,100,000	1,055,450	
Gulf of Alaska	196,933	170,640	
Total	1,296,933	1,226,090	1,558
North Atlantic			
Silver hake	55,000	19,400	18,485
Red hake	22,000	5,500	2,420
Atlantic cod	45,570[2]		43,575
Grand total	1,419,503	1,250,990	66,038
Total U.S. landings			
Menhaden			995,007
Other finfish			1,234,031
All finfish & shellfish			2,711,181

[1]Source: USDC (1981a).
[2]Represents 1981 actual harvest.

Table 2.—Prices for common hotdog ingredients, 1982 dollars.

Ingredients	Price
Fresh boneless beef[1]	
50 percent lean trimmings	$0.43
75 percent lean trimmings	0.69
85 percent lean trimmings	1.02
Fresh pork sausage materials[1]	
50 percent lean trimmings	0.43
80 percent lean trimmings	0.80
Chicken[2]	
Mechanically deboned (meat and skin)	0.25
Mechanically deboned (meat only)	0.35

[1]Source: *National Provisioner* (1982:31).
[2]Source: Jim Bacus, Vice President, ABC Research Corporation, 3437 S.W. 24th Ave., Gainesville, FL 32607. Pers. commun.

silver hake are assumed since no detailed cost data were available. Since all values in this paper are reported in 1982 dollars, adjustments to the values in the Combs' report, which are in 1979 dollars, were required. The Consumer Price Index (USDL, 1982) for all items was used to adjust for inflation except where more specialized indices were available, as in the case of fuels, shipping costs, utilities, wages for processing labor, and food[2].

For harvesting and processing walleye pollock, two scenarios are investigated: 1) Harvesting with shore processing and 2) a catcher/processor vessel. In the first scenario, Combs assumed an 85-foot trawler targeting on walleye pollock (Combs, 1979:329) and a shore facility processing a variety of Alaska bottom fish (Combs, 1979:59). For a catcher/processor, a 250-foot vessel targeting on walleye pollock (Combs, 1979:61) is assumed. A variety of outputs from processing operations is assumed by Combs including frozen fillets, frozen fillet blocks, frozen minced blocks, and fish meal. Also when roe-laden fish are available, Combs assumes processors will produce this specialty product. Given the available data, it is not possible to isolate costs for each species and product type. Thus walleye pollock costs represent an average of several product forms. Cooked sausage products would utilize frozen fillets as well as frozen blocks (fillet or mince). Input costs per pound are computed by dividing total costs (variable plus fixed) by total catch. These results appear in Table 3. The calculations are straightforward except for the fact that the skipper and crew are generally paid in shares of catch (40 percent) rather than in wages and salaries. Thus the value of the catch must be determined before skipper and crew expenses can be calculated. Skipper and crew expenses were computed by assuming alternative values of walleye pollock catches of $0.05, $0.10, and $0.15 per pound ex-vessel, live-weight basis. Labor expenses were treated as a variable cost in the harvesting operation. Thus, there are three sets of harvesting variable and total costs, depending on the assumed ex-vessel price of fish. Fixed costs are unaffected by ex-vessel prices.

An alternative approach is to ignore skipper and crew expenses and also net out skipper and crew share (i.e., 40 percent) from total catch. All cost items are thus divided by 60 percent of total catch which reflects the owner's share. These calculations appear in parentheses in Table 3. This approach makes it unnecessary to assume a set of ex-vessel market prices for fish harvested.

The two approaches are equivalent in deriving total cost per unit (i.e., average total cost or ATC) when the price paid the skipper and crew for their share of the catch equals the ATC of the owner's share. For example, in Table 3 when an ex-vessel price of $0.10 per pound is assumed, the two approaches converge and yield ATC of $0.099 and $0.098, respectively. In this case the owner is breaking even, and it makes no appreciable difference how we proceed. However, when the ex-vessel price (P) exceeds ATC and the owner is making a profit (e.g., when $P = \$0.15$), ATC is lower when skipper and crew are netted out of the calculations ($\$0.098 < \$0.119$). Alternatively when the ex-vessel price (P) is less than ATC and the owner is incurring a loss (e.g., when $P = \$0.05$), ATC is higher when skipper and crew share are netted out ($\$0.098 > \$0.079$).

Although the two approaches may not deviate significantly in the calculation of ATC, they differ greatly in their allocations between average variable and average fixed costs. When labor costs are ignored and skipper and crew share is netted out of output, average variable cost is systematically lowered and average fixed cost is increased. This change in allocation between average variable cost and average fixed cost can be important for short-run marginal decisions. Since an operator will continue operating in the short run if price covers average variable cost, anything that affects average variable costs can be important.

All of this may be academic since Table 3 indicates that a catcher/processor mode of production results in lower costs. For a catcher/processor operation, skipper and crew shares are less important and not isolated in the data available. Thus, the ambiguity caused by the two accounting allocation approaches is avoided.

In Table 4, average variable costs and average total costs are converted from an input to an output basis by assuming various yield percentages. These calculations were performed by dividing the numbers in Table 3 by alternative yield percentages. Since only average variable costs and average total costs are relevant for short run and long run decisions respectively, average fixed costs are not reported on an output basis. Table 4 indicates that average costs are extremely sensitive to yield assumptions. The range of average total cost for walleye pollock using the least cost opera-

Table 3.—Production costs per pound of input for walleye pollock, 1982 dollars[1].

	Mode of production							
	Shore processing							Catcher/processor
Cost type	Harvesting			Processing	Total			Total
	Ex-vessel price				*Ex-vessel price*			
	$0.05	*$0.10*	*$0.15*		*$0.05*	*$0.10*	*$0.15*	
Variable	0.045	0.065 [2](0.041)	0.085	0.238	0.283	0.303 (0.279)	0.323	$0.209
Fixed[3]		0.034 (0.057)		0.038		0.072 (0.095)		0.098
Total	0.079	0.099 (0.098)	0.119	0.276	0.335	0.375 (0.374)	0.395	0.307

[1]Outputs from processing operations include frozen fillets and frozen blocks (fillet and mince).
[2]Numbers in parenthesis reflect alternative approach in dealing with skipper and crew share in harvesting, and are independent of ex-vessel prices.
[3]Fixed costs do not depend on ex-vessel price assumptions.

[2]John Vondruska, Economist, National Marine Fisheries Service, NOAA, Washington, DC 20235. Pers. commun.

tion (i.e., a catcher/processor) is $0.61 to $1.02 per pound for an assortment of output including frozen fillets and frozen blocks (fillet and mince). For average variable cost, which is relevant in the short run, the range is $0.42 to $0.70.

Similar calculations were performed for silver hake using Combs' data which assumed an 85-foot otter trawler and a shore facility processing a mixture of defatted fillet blocks and minced blocks (Combs, 1979:206-207). Average costs per pound of input and output for silver hake are found in Tables 5 and 6 respectively. The data available do not allow us to isolate costs by product type. Thus silver hake costs reflect an average of frozen blocks (fillet and mince). Yield assumptions again have a much larger effect on average costs than do ex-vessel price assumptions. From Table 6 we see that average total cost varies from a low of $0.68 per pound of output to a high of $1.27 per pound depending on assumptions. A comparison of walleye pollock and silver hake costs for the shore-based processing model reveals lower harvesting costs but higher processing costs for walleye pollock. These offsetting factors result in very similar total (harvesting plus processing) costs for walleye pollock and silver hake. When a catcher/processor operation is used for walleye pollock, however, average costs are lower for it than for silver hake.

Table 4.—Production costs per pound of output for walleye pollock, 1982 dollars[1].

	Mode of production							
	Harvesting and shore processing						Catcher/processor	
Yield	Variable			Total			Variable	Total
	Ex-vessel price			*Ex-vessel price*				
	$0.05	*$0.10*	*$0.15*	*$0.05*	*$0.10*	*$0.15*		
30 Percent	0.94	1.01 [2](0.93)	1.08	1.18	1.25 (1.25)	1.32	$0.70	$1.02
40 Percent	0.71	0.76 (0.70)	0.81	0.89	0.94 (0.94)	0.99	0.52	0.77
50 Percent	0.57	0.61 (0.56)	0.65	0.71	0.75 (0.75)	0.79	0.42	0.61

[1]Outputs from processing operations include frozen fillets and frozen blocks (fillet and mince).
[2]Numbers in parenthesis reflect an alternative approach in dealing with skipper and crew share in harvesting, and are independent of ex-vessel price.

Table 5.—Production costs per pound of input for silver hake, 1982 dollars[1].

	Production stage						
Cost type	Harvesting			Shore processing	Total		
	Ex-vessel price				*Ex-vessel price*		
	$0.10	*$0.15*	*$0.20*		*$0.10*	*$0.15*	*$0.20*
Variable	0.088	0.108 [2](0.080)	0.128	$0.172	0.260	0.280 (0.252)	0.300
Fixed[3]		0.048 (0.079)		0.034		0.082 (0.113)	
Total	0.136	0.156 (0.159)	0 176	0.206	0.342	0.362 (0.365)	0.382

[1]Outputs from processing operations include frozen blocks (fillet and mince).
[2]Numbers in parenthesis reflect alternative approach in dealing with skipper and crew share in harvesting, and are independent of ex-vessel price.
[3]Fixed costs do not depend on ex-vessel price assumptions.

Table 6.—Production costs per pound of output for silver hake, 1982 dollars[1].

	Harvesting and shore processing					
Yield	Variable			Total		
	Ex-vessel price			*Ex-vessel price*		
	$0.10	*$0.15*	*$0.20*	*$0.10*	*$0.15*	*$0.20*
30 Percent	0.87	0.93 [2](0.84)	1.00	1.14	1.21 (1.22)	1.27
40 Percent	0.65	0.70 (0.63)	0.75	0.86	0.91 (0.91)	0.96
50 Percent	0.52	0.56 (0.50)	0.60	0.68	0.72 (0.73)	0.76

[1]Outputs from processing operations include frozen blocks (fillet and mince).
[2]Numbers in parenthesis reflect alternative approach in dealing with skipper and crew share in harvesting, and are independent of ex-vessel price.

Competitiveness of Minced Fish

Table 7 presents average frozen block prices for selected species along with the range of costs for walleye pollock and silver hake found in Tables 4 and 6. Ex-vessel prices are also included for reference. Under some assumptions, the

Table 7.—Average prices and costs for selected species and form (dollars per pound)[1].

Species and form	Average frozen block price[2] 1981	Average frozen block price[2] 1982[4]	Ex-vessel price 1982	Cost range[3] (1982 $)[2] High	Cost range[3] (1982 $)[2] Low
Walleye pollock			$0.149	$1.02	$0.61
Regular	$0.805	$0.175		(0.70)	(0.42)
Minced	0.400	0.350			
Silver hake	0.743	0.603	0.202	1.27 (1.00)	0.68 (0.50)
Atl. cod			0.329		
Regular	1.092	1.080			
Minced	0.511	0.503			
Red hake			0.169		

[1]Source: USDC (1982b).
[2]Block prices reflect import prices since over 99 percent of U.S. frozen fish blocks have been imported in recent years (USDC, 1982a).
[3]Costs for walleye pollock represent a catcher/processor mode. Numbers in parentheses reflect average variable costs only.
[4]July.

domestic production cost exceeds market prices which reflect import prices since over 99 percent of fish blocks in the United States are imported (USDC, 1982:69). Thus, there is some possibility that the domestic fishing industry may be uncompetitive with foreign fish sources in providing ingredients for cooked sausage products. It should be noted that there is considerable uncertainty in the domestic cost estimates depending on yield factors and market conditions. In addition, producer profits, taxes, and land costs have been excluded from the domestic cost figures. These omissions in the data which tend to underestimate costs may be offset, however, by technological change and economies of scale which could accompany an expansion of the U.S. fish harvesting and processing industries. The concern about domestic industry competitiveness was also expressed by Stokes and Offord (1981) who found that without a 25 percent increase in wholesale fillet and fillet block prices, development of Alaska groundfish was not financially feasible.

Given the cost and price information presented for fish and cooked sausage ingredients, it is apparent that minced fish can be price competitive with beef and pork as a cooked sausage ingredient. Whether the U.S. domestic fish industry, which is best reflected by the production cost calculations rather than frozen block prices, can be price competitive with existing cooked sausage ingredients is not entirely clear. It seems likely that domestically produced fish would not be price competitive with poultry and less-lean meat as an ingredient in frankfurters. Domestically produced minced fish would be price competitive with the higher quality meat ingredients, however.

Since minced fish is high in nutritional quality, it seems more appropriate to fit it into the higher quality end of the cooked sausage market where it appears to be price competitive. Table 8 summarizes some of the relevant nutritional aspects of existing frankfurters and ingredients including fish. The high quality of minced fish as a potential ingredient in frankfurters is clearly demonstrated. For example, if we compare

Table 8.—Nutritional attributes of fish, beef, pork, poultry, and frankfurter types[1].

	Amount in edible portion of 1 pound of food purchased				
Product	Food energy (k cal)	Protein (g)	Total fat (g)	Cholesterol[2] (mg)	Carbohydrate (g)
Fish					
Walleye pollock					
Fillets	431	92.5	4.1		0.0
Minced (frozen)	330	75.4	3.0		0.0
Atlantic cod (flesh)	354	79.8	1.4		0.0
Silver hake (flesh)	336	74.8	1.8		0.0
Red hake (flesh)	336	74.8	1.8		0.0
Beef, fresh					
Carcass with bone (standard grade)	847	73.0	59.5		0.0
Chuck (no bone) (82% lean)	1,166	84.8	88.9		0.0
Pork, fresh					
Carcass with bone (medium fat class)	1,827	36.3	185.2		0.0
Lean cuts, no bone or skin (medium fat class, 77% lean)	1,397	71.2	121.1		0.0
Chicken fryer, ready to cook					
With bone	382	57.4	15.1		0.0
Without bone (95% lean)	562	84.4	22.2		0.0
Cooked sausage products					
Beef frankfurter	1,462	51.2	133.4	218	10.9
Beef and pork frankfurter	1,454	51.2	132.2	227	11.6
Chicken frankfurter	1,167	58.7	88.3	456	30.8
Cheesefurter (includes beef and pork)	1,483	63.7	131.3	308	6.8
Beef frankfurter with fish (15% frozen minced walleye pollock)	1,365	63.0	114.0		4.5

[1]Sources: USDA (1963) for fish, beef, pork, and poultry data; USDA (1980b) for frankfurter data. Values for minced walleye pollock and beef frankfurters with fish were obtained from ABC Research Corporation (1982).
[2]Data unavailable except for cooked sausage products listed.

regular walleye pollock blocks with beef (82-85 percent lean) using Tables 2, 7, and 8, we see a comparable protein content, a much lower fat content, and a significantly lower price (e.g., \$0.72 vs. \$1.02 per pound) for walleye pollock. In Table 9 the price data are related to protein content. One obtains a lower cost for walleye pollock protein (\$4.34 per pound) than for beef protein (\$5.45 per pound), though not as low as that for chicken meat protein (\$1.88 per pound). Thus, there is the potential that cooked sausage formulations could use minced fish as an optional ingredient at up to 15 percent of the final product weight to alter nutritive values and production costs. The lower fat content of minced fish would offer formulators more options in ingredient mixes to achieve specified fat content.

With a quality oriented marketing strategy, and a competitive price which appears feasible, there is a potential market to utilize part of the TALFF for the species under consideration. If we assume harvesting and mincing of the

Table 9.—Prices, protein content, and protein cost of selected boneless products[1].

Product	Price per pound	Grams of protein per pound of product (pounds)	Cost per pound of protein
Beef, 82-85% lean	$1.02	84.8 [2](0.187)	$5.45
Pork, 77-85% lean	0.80	71.2 (0.157)	5.10
Chicken meat, 95% lean	0.35	84.4 (0.186)	1.88
Minced walleye pollock, 99% lean	0.61	75.4 (0.166)	3.67
	0.72	75.4 (0.166)	4.34
	1.02	75.4 (0.166)	6.14

[1]Source: Tables 2, 7, 8.
[2]In parentheses are pounds of protein per pound of product.

entire TALFF for walleye pollock, silver hake, and red hake at yields of 30-50 percent, we obtain a new domestic supply of 0.8-1.4 billion pounds. Perhaps

U.S. cooked sausage products might absorb 0.1 billion pounds or approximately 10 percent of the TALFF.

Impacts of Minced Fish

Including up to 15 percent minced fish in cooked sausage products will likely have a small impact on both the U.S. cooked sausage market and domestic fisheries. Some impacts will be felt but we can only speculate as to what they might be. In the analysis by Combs (1979:63-70), it was estimated that after 10 years around 14,000 jobs and annual wages of around $250 million (1979 dollars) would be created if the entire TALFF of walleye pollock were absorbed by the domestic harvesting and processing industries. Inclusion of up to 15 percent minced fish meat in cooked sausage products, by absorbing 10 percent of the TALFF, might thus create on the order of 1,400 jobs in the fish harvesting and processing sectors. If the domestic industry were not price competitive, the job creation potential would diminish.

The impact on employment in the U.S. agriculture sector is difficult to determine since it is unclear whether minced fish would complement or substitute for existing ingredients. If consumers responded favorably to the higher protein and lower fat opportunities afforded by minced fish, an expansion of the cooked sausage market would result. In this case, both the fishing and agriculture sectors would benefit.

To the extent that the cooked sausage market would not expand with the minced fish option, minced fish would displace some pork, beef, and poultry. The net employment impact, if the U.S. fishing industry were to supply most of the minced fish for cooked sausage, would probably be positive. This conclusion is based on a higher labor intensity in the U.S. fishing sector than U.S. agriculture. Although the evidence is scanty, from Combs (1979) we can compute labor's share of total cost in several fishing operations. For walleye pollock (shore processing and a catcher/processor) and silver hake (shore processing only), we compute direct labor cost shares of 0.285, 0.274, and 0.402, respectively (Combs, 1979:59, 61, 207). These labor shares in fishing operations are higher than 0.20 which is labor's share in all agriculture derived from a rough calculation performed for the United States in 1979 (USDA, 1980a:431, 464). Labor's share in agriculture was derived by dividing total expenses in agriculture (including an imputed payment for family workers based on a wage equal to that of hired workers) by the sum of payments to hired workers and imputed payments to family workers. Since the assumptions of no market expansion for cooked sausage and no foreign involvement in supplying minced fish are not likely to be accurate, the impact on U.S. agriculture is very difficult to determine. It's probably safe to say, however, that the impacts on agriculture (positive or negative) will be small.

Conclusion

It appears that allowing the use of minced fish in cooked sausage products has potential from an economic point of view. Although modest in size, a market in which minced fish can successfully compete with existing cooked sausage ingredients seems to exist. Benefits from such a proposal would accrue to the U.S. fishing industry as well as the cooked sausage industry. The former would be provided with the opportunity for wider use of underutilized species through expanded markets while the latter would benefit from more flexibility with respect to cost and nutritional formulations for cooked sausage. If foreign vessels supplied most of the minced fish for cooked sausage, benefits would still accrue to the United States through an increase in value of stocks and opportunities for increases in foreign fees. Negative impacts on traditional suppliers of cooked sausage ingredients appear small.

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Chemical Composition and Frozen Storage Stability of Weakfish, *Cynoscion regalis*

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ABSTRACT—Weakfish, Cynoscion regalis, *were harvested seasonally for a 12-month period to determine the chemical composition and frozen storage (−18°C) stability of fillets, minced flesh, and washed minced flesh. One-pound blocks were prepared, frozen, and evaluated after 0, 3, 6, and 12 months of storage. The results showed that harvesting season and frozen storage had little effect on the chemical properties of the flesh. However, TBA values (rancidity) increased slightly during 6 months of storage, then decreased. Mincing increased rancidity during storage, but the rancidity was minimized by washing. Total volatile nitrogen and trimethylamine-nitrogen values indicated that the fish were of good quality when processed. No clear-cut trends existed in the fatty acid composition during storage, though there was some suggestion of a slight loss of 22:6ω3 in the minced form after 12 months. Washing the minced flesh improved its storage stability, color, flavor, odor, and overall appearance.*

Sensory scores showed that weakfish fillets were preferred over the washed and unwashed minced forms due to better texture, flavor, odor, and lighter color. Lighter color was primarily responsible for the preference of fillets over other products. Instrumental results showed comparable L-values (lightness) between fillets and washed mince, but both were notably higher than those for unwashed mince. Processing yields for weakfish were 37 percent for hand-processed fillets and 49 percent for the minced flesh. Washing the flesh resulted in 3-4 percent loss of solids and accounted for decreased values for the fat and protein content of the minced product.

Introduction

Weakfish, *Cynoscion regalis*, is a species important to both recreational and commercial fisheries in the United States and is grouped under the general category of groundfish. They are found along the Atlantic coast from southern Florida to Massachusetts Bay, straying occasionally to Nova Scotia (Wilk, 1979). Occasionally they are caught off Marco Island, Fla. (Weinstein and Yerger, 1976) proving the presence of this species in the Gulf of Mexico. Spawning, hatching, and early larval development take place in the near-shore and estuarine zones along the coast from May to October with peak production during late April through June (Wilk, 1978).

Weakfish are harvested principally with fish traps (pound nets) and secondarily with hook and line, haul seines, and purse seines (Wilk and Brown, 1982). The bulk of the catch is made in the Mid-Atlantic and southern New England regions. Weakfish are also caught incidentally in the shrimp fishery. The sizes of weakfish found in the average commercial catch range from about 200 g to about 2,300 g. Wilk (1979) reported that weakfish can reach 17 pounds (7,718 g), and he examined a 9-year-old fish weighing approximately 13 pounds (5,902 g). Pellegrin (1981) reported that 5 of the top 10 fish species harvested annually by the shrimp fleet in the South Atlantic are sciaenids, predominately spot, croaker, and weakfish. Keiser (1977), evaluating the incidental catch from commercial shrimp trawlers of the South Atlantic states, showed that small weakfish (less than 250 g) accounted for 3.9, 3.0, and 6.9 percent of the shrimp by-catch discarded at sea by vessels operating from North Carolina, South Carolina, and Georgia ports, respectively. Market-sized fish harvested with the shrimp catch are separated and sold dockside as food fish. Considering that 5 percent of the reported 66 million pounds of the discarded by-catch in the South Atlantic area are weakfish, 3.3 million additional pounds of this species could be made available for human consumption with little additional effort and cost to the fishermen.

Landing of weakfish contributes substantially to the U.S. economy. A considerable number are caught by recreational fishermen, according to available statistics, but the number is believed to be conservative due to an inadequate reporting system. In 1979 (latest data available), the U.S. recreational catch totaled 4.5 million fish and the 1981 commercial catch totaled 26.5 million pounds valued at $9.1 million; the 5-year average (1977-81) totaled 26.4 million pounds (USDC, 1982).

Weakfish are highly perishable and must be handled expeditiously, even when properly stored, to maintain good quality at the retail level. The texture of the flesh is soft and the fish feed on highly proteolytic material, resulting in a short shelf life after capture. These factors probably play a major role in the underutilization of the species. On the positive side, however, the flesh is relatively light in color (compared with other groundfish species), is considered

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low to medium oily, and possesses a pleasant fish flavor when fresh. Weakfish are readily available in restaurants and seafood markets in coastal areas where landed.

Mincing technology, introduced to the United States about 1970, offers a unique opportunity to utilize the smaller weakfish (shrimp fishery discards), and to use the oversupply of larger fish in fabricated and reshaped products. These product forms can take advantage of the characteristic soft texture of the weakfish where different textural properties can be expected. However, fabricated and reshaped products should not be used as an escape route for utilizing soft-textured weakfish caused by low quality fish.

Investigations in the use of weakfish in minced food products have not been reported, yet this species may offer good potential, economically and technologically, due to its availability, high yield of minced flesh, ease in processing, and favorable minced product characteristics. Preliminary investigations in our laboratory indicated that weakfish possess several characteristics that are desirable in minced fish products. To further determine if this species is a suitable candidate for minced fish products, expanded investigations were required. The purpose of this study was to determine the seasonal chemical composition of weakfish and evaluate the effect of composition on the frozen storage stability of fillet blocks and washed and unwashed mince blocks as an intermediary for further processing.

Materials and Methods

Sample Preparation

Fresh, iced weakfish were obtained during March, May, July, September, and December 1980 and January 1981 from a commercial seafood dealer in North Carolina. In each sampling period, 150 pounds were obtained dockside, reiced, and transported to the NMFS Southeast Fisheries Center's Charleston Laboratory for processing. The fish were caught off the coast of Morehead City, N.C., 36-48 hours before sample preparation. They ranged in size from 326 to 789 g with an average weight of about 495 g.

Preparation of fillet and mince blocks began immediately upon arrival of the fish at the laboratory. The fish were washed, divided into two groups, and weights obtained for subsequent calculation of product yield. The first group (60 pounds) was hand filleted and skinned; fillets were weighed, rinsed in ice water, and drained 5 minutes. The fillets (F) were packed in 1-pound, wax-coated food cartons (7.5 × 21.5 × 3 cm). The second group (90 pounds) was mechanically scaled, headed, gutted, and deboned, and the resulting minced flesh weighed. The minced flesh was divided equally into two lots, one of which was packed in 1-pound waxed food cartons and designated as unwashed mince (UWM). The second lot was washed in cold tap water (8°C) according to the procedure outlined by Rasekh et al. (1980). The washed flesh was pressed to remove the wash water to equal the initial prewashed weight. The washed flesh was packed in 1-pound waxed food cartons and designated as washed mince (WM). The fillet and minced fish blocks were frozen in a plate freezer at −40°C under pressure, overwrapped with polyvinyl chloride (PVC) packaging material and stored at −18°C for 12 months. Ten 1-pound fillet blocks were stored at −40°C as a reference for sensory evaluations.

Product Evaluation

Three blocks each of filleted, UWM, and WM weakfish were evaluated organoleptically, physically, and chemically after 0, 3, 6, and 12 months of storage at −18°C. Two fillet blocks stored at −40°C were used as a reference sample for sensory comparison. Physical and chemical values are reported as an average of three analyses.

Sensory Evaluation

Sticks (1.3 × 7.6 × 3 cm) were cut from frozen fillet, UWM, and WM blocks and reference samples, which were battered, breaded, and fried approximately 1.5 minutes in vegetable oil at 182°C. The sticks were cooled, wrapped in aluminum foil, and frozen at −18°C. They were removed from storage the next day, cooked approximately 15 minutes in an oven heated to 204°C, and served to a 12-member taste panel.

The panel rated the samples for color, flavor, firmness, odor, and overall acceptability on a scale of 1-5. Sensory attributes were rated from 1 = most acceptable to 5 = least acceptable.

The reference samples, used as the sensory control, were stored at −40°C to minimize sensory changes due to storage. Reference samples were prepared each sample period and compared to stored samples of that sampling period so as to be more nearly representative of those samples.

Physical Measurements

Color values (L = lightness, a = redness, b = yellowness) were determined on a 6.5 cm^2 portion from each block, using a Hunter-lab[1] color and color-difference meter. Two values were obtained from each of two sides of the portion by rotating the portion 90° after the first reading. The color value for each portion is, therefore, an average of four readings.

Shear force (texture) values were obtained on 110 g portions of each block at a product temperature of 6°C, using the Kramer Shear press (Kramer and Twigg, 1966). Values are reported as total pounds of shear force.

Chemical Analyses

Samples used for thiobarbituric acid (TBA) analyses were cut from near the center of each frozen block so as to be truly representative of the total exposed area; samples were homogenized only after addition of the extracting solution. Samples for the remaining chemical analyses were passed through a meat grinder three times to obtain a homogeneous mixture. Ground samples for proximate composition, amino acid, and fatty acid analyses were placed separately in vapor-proof containers, frozen and held at −40°C until analyzed. Proximate analyses and pH determina-

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

tions were conducted according to the AOAC method (AOAC, 1975). Fat was measured according to the Bligh-Dyer method as modified by Smith et al. (1964). Thiobarbituric acid determinations were performed as a measure of oxidative rancidity using Vyncke's direct extraction method (Vyncke, 1972) and results are expressed as mg malonaldehyde (MA)/kg tissue. Total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) were determined as described by Cobb et al. (1973). Fatty acid profiles were obtained by gas chromatography on methyl esters of the extracted lipids (Metcalfe et al., 1966).

Samples for amino acid analysis were prepared initially by drying duplicate samples 2 days in a Virtis model FFD-15-W5 freeze dryer. Moisture-free samples were then extracted with petroleum ether for 8 hours in a Soxlet extraction apparatus to remove the lipids. The dry, lipid-free samples were ground to pass a 40-mesh screen in a Cyclo-Tech sample grinding mill. Crude protein (N × 6.25) was determined on the ground samples by the Kjeldahl method (AOAC, 1975). Amino acids, other than methionine, cystine, and tryptophan, were determined by the method of Spackman et al. (1958). Ground samples were weighed into hydrolysis tubes containing 6 N hydrochloric acid, evacuated, sealed, and hydrolyzed 22 hours with rotation in a 110°C forced air oven. Contents of each tube were evaporated to dryness on a Buchler rotary evaporator and diluted to volume with sodium citrate buffer. The samples were then analyzed for total amino acid content on a Dionex Amino Acid/Peptide Analyzer Kit, Model MBN/SS. Methionine and cystine content were determined with a performic acid oxidation pretreatment before normal hydrolysis as described above and according to the method of Moore (1963). Tryptophan content was determined by hydrolysis as described above, except that 4 N methane-sulfonic acid containing 0.2 percent 3-(2-aminoethyl) indole was substituted for the 6 N hydrochloric acid. These samples were then chromatographed on the basic column of a Phoenix Amino Acid analyzer, Model K-8000 VG.

Table 1.—Mean and range of values for proximate composition of filleted, washed mince (WM), and unwashed minced (UWM) weakfish stored 12 months at −18°C.

Month and year harvested	Product form	Mean Range	Proximate composition (%) Moisture	Protein	Fat	Ash	NPN
March 1980	Fillet	Mean	80.54	17.62	1.87	1.12	0.06
		Range	80.39-80.82	17.06-18.06	1.38-2.21	1.00-1.38	0.01-0.13
	WM	Mean	83.41	14.18	2.30	0.49	0.04
		Range	81.64-84.52	13.19-15.63	1.78-2.67	0.46-0.52	0.01-0.06
	UWM	Mean	80.41	16.85	2.56	1.02	0.09
		Range	80.20-80.69	16.50-17.34	2.32-2.74	0.95-1.07	0.01-0.18
May 1980	Fillet	Mean	80.02	18.58	1.45	1.15	0.06
		Range	79.65-80.62	18.21-18.94	0.99-1.65	1.03-1.46	0.02-0.12
	WM	Mean	83.35	15.69	1.67	0.56	0.08
		Range	82.69-84.65	15.39-16.25	1.38-1.88	0.48-0.63	0.02-0.23
	UWM	Mean	79.24	18.14	2.50	1.05	0.11
		Range	78.44-80.29	17.72-18.55	1.76-2.86	0.96-1.22	0.02-0.31
July 1980	Fillet	Mean	78.83	18.47	2.81	1.00	0.05
		Range	78.35-79.30	17.60-19.34	2.57-3.18	0.92-1.06	0.02-0.11
	WM	Mean	82.14	15.90	2.22	0.48	0.06
		Range	81.70-82.48	15.41-16.13	2.13-2.31	0.44-0.51	0.02-0.10
	UWM	Mean	79.09	18.34	2.59	1.02	0.05
		Range	78.85-79.29	17.98-18.69	2.47-2.75	0.98-1.06	0.02-0.09
September 1980	Fillet	Mean	80.87	18.27	1.01	1.05	0.07
		Range	80.68-81.32	17.93-18.49	0.81-1.24	1.00-1.07	0.02-0.15
	WM	Mean	82.81	16.15	1.43	0.82	0.07
		Range	80.47-83.85	15.33-18.07	1.32-1.64	0.47-1.21	0.01-0.14
	UWM	Mean	80.97	17.67	1.52	0.95	0.08
		Range	80.43-82.05	16.93-18.41	1.33-1.68	0.57-1.15	0.02-0.18
December 1980	Fillet	Mean	76.54	17.81	5.35	0.94	0.06
		Range	75.74-77.24	17.44-18.25	4.96-5.95	0.88-0.99	0.02-0.08
	WM	Mean	81.00	13.92	4.55	0.45	0.04
		Range	80.62-81.23	13.22-14.65	4.34-4.89	0.41-0.49	0.01-0.06
	UWM	Mean	76.08	18.23	5.36	1.02	0.07
		Range	75.67-76.30	17.84-18.71	5.07-5.55	0.96-1.05	0.02-0.10
January 1981	Fillet	Mean	77.74	18.10	4.27	1.02	0.06
		Range	77.48-77.92	17.41-18.52	3.84-4.76	0.96-1.07	0.01-0.10
	WM	Mean	81.14	15.37	3.80	0.54	0.05
		Range	80.58-81.65	15.01-15.73	3.55-4.00	0.51-0.60	0.01-0.10
	UWM	Mean	77.37	17.61	4.61	1.07	0.07
		Range	76.76-78.05	16.64-18.28	4.26-5.09	0.98-1.24	0.02-0.13

Results and Discussion

Processing yields for weakfish were 37 percent for hand-processed fillets and 49 percent for the minced flesh.

The proximate composition of fillet, WM, and UWM blocks is presented in Table 1. The mean and range of values are shown for the 12-month storage period. An inverse relationship exists between the moisture and fat content of seasonally harvested fish, i.e., when the moisture was highest, the fat content was minimal. The moisture content of fillets and UWM closely paralleled each other during seasonal harvest, and values were highest in September, toward the end of spawning, and lowest in December after spawning. Conversely, the fat content was highest in December and lowest in September for all three product forms. The moisture content of WM was somewhat higher than the other forms (2-4 percent) reflecting the loss of solids and its replacement with moisture. In a preliminary experiment, it was determined that washing minced flesh removed from 3 to 4 percent of the solids (proteins, fat, etc.). This was replaced by water when the flesh was pressed to the prewashed weight. This loss in solids accounts for the lower fat and protein content of the WM samples. The fat content of fillet blocks was slightly less than that of the other forms in March, May, and September. This could be attributed to the concentration of depot fat, adjacent to the skin during these months, which was removed during the skinning process. Eide et al. (1982), investigating methods for gutting, skinning, and removing the fat from small fatty fish, referenced work that showed most of the depot fat in fat cells of capelin is concen-

trated in the peritoneum and beneath the skin. The protein and ash content remained fairly stable throughout all months of harvest. The ash content was least for the WM samples due to leaching of minerals, the washing out of scales and small bone particles, and the increase in moisture content. The nonprotein nitrogen (NPN) content generally remained below 0.1 percent except for the May sample stored for 3 months. Values for all proximate composition factors did not vary appreciably during storage.

The TBA, TVN, and shear values for fillet, WM, and UWM blocks are shown in Table 2. Overall, TBA values were lowest in fish obtained in September and remained low during the storage period. The low TBA values corresponded well with the low fat content for September. Thiobarbituric acid values were least for fillet blocks, followed by WM blocks, and highest for UWM fish, corresponding well with the fat content of these forms. The TBA values of all product forms during storage was somewhat erratic; values for December and January fish peaked at 12 months, others peaked at 6 months.

Table 2.—The TBA, TVN, and shear values of filleted, washed mince (WM) and unwashed mince (UWM) blocks of weakfish stored 12 months at −18°C.

Month and year harvested	Product form	TBA (mg MA/kg) Months in storage				TVN (mg N/100g) Months in storage				Shear force (lb force) Months in storage			
		0	3	6	12	0	3	6	12	0	3	6	12
March 1980	Fillet	0.58	0.84	2.06	2.36	6.75	8.50	8.89	10.56	422	382	345	500
	WM	2.30	2.00	3.01	2.01	3.09	6.74	4.12	6.26	87	125	168	143
	UWM	1.71	2.01	5.67	3.66	6.66	8.57	8.82	9.98	66	78	103	111
May 1980	Fillet	0.51	0.72	0.62	0.56	9.92	9.95	15.01	13.05	565	243	485	337
	WM	0.87	1.30	1.22	0.97	7.37	5.95	8.18	7.85	105	143	151	157
	UWM	2.86	2.02	2.83	2.40	9.98	9.78	12.82	12.00	70	83	84	93
July 1980	Fillet	2.17	1.04	2.23	1.16	10.75	11.37	11.40	12.93	388	495	555	508
	WM	2.10	1.36	3.20	1.43	5.69	8.08	8.23	9.96	107	117	118	131
	UWM	3.44	1.76	5.86	2.34	10.63	12.27	14.54	15.84	77	78	79	86
September 1980	Fillet	0.70	0.30	0.68	0.33	12.92	13.20	13.74	11.77	583	680	592	693
	WM	0.77	0.96	0.82	0.37	7.70	7.41	8.23	6.68	156	216	139	137
	UWM	0.79	0.84	1.27	0.43	12.13	13.32	13.20	11.38	100	102	87	86
December 1980	Fillet	1.00	1.39	1.49	1.47	10.52	10.21	12.40	9.13	413	593	635	460
	WM	1.94	1.59	1.23	2.69	7.20	6.57	6.24	5.43	85	113	116	105
	UWM	2.70	4.03	2.86	4.80	11.95	11.26	12.16	9.64	66	62	71	67
January 1981	Fillet	0.87	0.91	0.76	3.73	12.27	14.70	12.56	9.08	450	485	525	503
	WM	1.48	0.93	1.71	2.35	12.71	11.35	10.63	5.78	95	115	121	121
	UWM	1.23	1.98	2.68	3.04	7.28	10.87	16.36	9.09	84	86	81	94

Total volatile nitrogen values fluctuated somewhat between months of harvest and during storage. The slight increase during storage is evidence of only minor proteolytic activity at −18°C as was expected. The TVN content was noticeably lower in the WM form (corresponding with removal of water soluble protein) and about equal in the other forms; maximum values did not exceed 16 mg N/100 g sample. Phillips and Cobb (1977) showed that 30 mg N/100 g fish is the maximum acceptable TVN level for edible quality iced fish.

The shear values for all products remained relatively stable between months of harvest and during the storage period. Shear values were greater for the fillet blocks reflecting the presence of connective tissue; values for the WM were consistently higher than those for the UWM. Fluctuation in values for fillets during storage may be attributed to the amount of connective tissue in the sample and age of the fish from which the fillets were derived. The lower values for the mince forms, as compared with the fillets, were due to the loss of tissue integrity during mincing.

The pH of weakfish was highest in March and lowest in July, approximately 7.0 and 6.5, respectively. Values decreased slightly during storage and values were always highest for the WM followed by the UWM.

Trimethylamine-nitrogen values for all product forms were low (0-2 mg N/100 g) for fish harvested during March, May, July, and September; values were slightly higher (2-4 mg N/100 g) for fish collected in December and January. Values remained fairly consistent during storage. Trimethylamine-nitrogen values of frozen fish indicates the extent of microbial spoilage before the muscle was frozen (Castell et al., 1974) and should not increase measurably during storage. The higher values for December and January may be due to improper handling and storage of the whole fish before preparation and freezing the samples.

The color values (L, a, b) for all product forms did not change significantly between months of harvest or during storage. The L values (lightness) for the fillet and WM forms were about the same and substantially higher than the UWM form. The a values (redness) for the UWM form were notably higher than the other forms, except in a few obvious isolated cases where the skin side of fillets contained dark flesh not removed during the skinning procedure. The red-brown color of the UWM flesh was due to the presence of oxidized blood pigments not removed before mincing. The b values (yellow) for all product forms were virtually unchanged and revealed no particular pattern of differences.

Sensory panel scores revealed that, in general, the color of the fillet form was most acceptable while the UWM form was least acceptable as compared with the reference sample (fillet blocks held at −40°C). The flavor and odor scores showed much the same consensus as the color while the firmness scores showed the panel's greatest acceptance for the fillet form followed by the UWM form. The WM form was slightly rubbery in texture and deviated considerably from that of the reference sample. Overall acceptability scores showed that the fillet form was equal to the reference sample and both were more acceptable than the WM and UWM forms. Only slight inconsistencies existed between acceptability scores for the WM and UWM forms and, generally speaking, the two

Table 3.—Percent amino acid and ammonia composition of proteins in filleted, washed, and unwashed minced weakfish harvested on a seasonal basis.

Amino acid and ammonia	Product form/month of harvest																	
	Fillet						Washed mince						Unwashed mince					
	Mar.[1]	May	July	Sept.	Dec.	Jan.	Mar.	May	July	Sept.	Dec.	Jan.	Mar.	May	July	Sept.	Dec.	Jan.
Tryptophan		1.13	1.14	1.02	1.04	1.15	1.20	1.03	1.04	1.09	1.13	1.19	1.14	1.00	1.12	1.05	1.09	1.04
Lysine		9.25	9.49	9.19	9.57	9.16	9.58	9.98	10.04	9.75	9.60	10.46	9.90	9.60	9.58	10.36	9.44	9.84
Histidine		1.82	2.28	1.72	2.05	2.01	2.01	2.01	2.04	1.85	2.02	2.12	2.09	2.07	2.04	2.02	1.82	2.03
Ammonia		1.13	1.19	1.02	1.29	1.52	1.01	1.07	1.07	1.08	1.22	1.17	1.09	1.13	0.99	1.02	1.09	1.17
Arginine		5.84	6.17	5.93	6.37	6.22	6.35	6.53	6.60	6.87	6.40	6.52	6.47	6.33	6.38	6.64	5.81	6.50
Aspartic acid		10.43	9.68	10.49	10.90	10.67	11.07	10.70	10.57	10.38	10.59	10.03	10.54	10.87	10.67	10.01	10.40	10.82
Threonine		4.73	4.49	4.87	4.64	4.63	4.87	4.76	4.68	4.77	4.75	4.71	4.79	4.70	4.66	5.02	4.82	4.68
Serine		4.31	3.98	4.40	4.09	4.09	4.22	4.25	4.22	4.19	4.11	4.20	4.17	4.27	4.15	4.16	4.37	4.24
Glutamic acid		16.29	15.88	16.61	16.47	16.67	15.94	17.33	17.47	16.99	17.13	15.57	15.98	17.00	17.11	15.78	16.77	16.68
Proline		3.63	6.32	3.88	3.39	3.34	3.28	3.28	3.43	3.33	3.50	3.59	3.24	3.28	3.63	3.58	3.77	3.10
Giycine		4.46	4.39	4.38	4.50	4.45	4.18	4.03	4.25	4.03	4.09	4.23	4.03	4.23	4.44	4.27	4.42	4.22
Alanine		6.17	5.74	6.16	6.05	6.11	6.01	6.04	6.00	6.01	5.92	6.22	5.89	5.92	5.87	6.35	6.11	6.07
Cystine		1.18	1.05	1.16	1.11	1.30	1.05	1.15	1.16	1.09	1.06	1.07	1.35	1.17	1.22	1.06	1.16	1.14
Valine		4.83	4.65	4.45	4.55	4.62	4.59	4.38	4.24	4.88	4.69	4.67	5.06	4.57	4.50	4.80	4.85	4.61
Methionine		3.59	3.19	3.64	3.24	3.48	3.37	3.53	3.59	3.57	3.29	3.29	3.54	3.49	3.42	3.43	3.49	3.40
Isoleucine		4.70	4.35	4.69	4.45	4.38	4.58	4.50	4.41	4.60	4.57	4.72	4.51	4.55	4.48	4.74	4.58	4.49
Leucine		8.59	8.20	8.60	8.21	8.19	8.38	8.39	8.31	8.41	8.31	8.51	8.50	8.42	8.48	8.47	8.43	8.40
Tyrosine		3.37	3.54	3.44	3.62	3.53	3.59	3.39	3.41	3.53	3.84	3.32	3.32	3.25	3.27	3.36	3.27	3.28
Phenylalanine		3.88	3.80	3.79	3.96	3.98	4.03	3.37	3.46	3.32	3.76	3.66	3.78	3.52	3.46	3.55	3.78	3.68
Taurine		0.66	0.47	0.55	0.50	0.52	0.69	0.27	Trace	0.28	Trace	0.75	0.61	0.63	0.54	0.31	0.53	0.63
Total		99.99	100.00	100.00	100.00	100.02	100.00	99.99	99.99	100.02	99.98	100.00	100.00	100.00	100.01	99.98	100.00	100.02

[1]Samples lost during storage.

forms were considered acceptable (score of 3.0) by the taste panel. The color and firmness attributes contributed the greatest toward lower acceptability of the UWM and WM, respectively.

The concentration of essential amino acids and ammonia of fillet, WM, and UWM weakfish is listed in Table 3 and expressed as a percentage of the protein content. Amino acid values were obtained only at 0 months of storage since these values should not change measurably when stored at −18°C. Values varied little between months of harvest and between product forms. Detailed analyses of values for four amino acids (arbitrarily selected) for the three product forms revealed that the tyrosine content was generally highest in the fillet and WM forms and lowest in the UWM form, while the phenylalanine and glycine content was highest in the fillet form and least in the UWM form; again variation in values were minimal. The threonine content was about equal in all forms. Mincing or washing the minced flesh did not seriously affect the amino acid content as compared with fillets.

Fatty acid values (seasonal mean and range for 12 months of storage) of fillet, WM, and UWM blocks are shown in Tables 4, 5, and 6, respectively, expressed as a percentage of total fatty acids. Although a complete profile was obtained, only the biochemically important components are shown. In examining the data, no clear-cut trends could be detected between the fatty acid composition of the filleted and minced forms of weakfish. Additionally, only minor differences existed between samples stored for various periods of time (i.e., 0, 3, 6, and 12 months). Consequently, values for the storage periods were combined and the mean and range are shown. There was, however, some suggestion of a slight loss of 22:6ω3[2] in the minced forms after 12 months of storage, primarily for fish obtained during March, May, and September. A number of factors could explain the apparent seasonal differences in composition. These include differences in average weight/length ratios and sexual composition of each population, the areas of capture, and the time-span between capture and processing. The fatty acid profile of weakfish is similar to that of spot, *Leiostomus xanthurus*, as shown by Waters (1982).

[2]Number of carbon atoms in the molecule and the number of double bonds. The number following the ω symbol indicates the position of the final double-bond with respect to the terminal methyl group of the molecule.

Conclusions

Based on the results of this study, I concluded that the moisture and fat content of weakfish were inversely proportional and reached maximum values in September and December, respectively. Washing the minced flesh improved the color, decreased the fat and protein content, and resulted in a 3-4 percent loss of solids. Mincing weakfish promoted rancidity development during frozen storage; rancidity was minimized by washing. Minimal TVN and TMA-N values indicated high-quality raw fish as experimental material and indicated minor proteolytic activity during storage. Seasonality of harvest had little affect on color, shear values, and amino acid content; fatty acid content varied somewhat and may or may not be a seasonal effect. Washing of the minced flesh did not appreciably affect its nutritional value and, was an overall improvement (flavor, color, and odor) over the unwashed flesh. Taste panelists preferred filleted weakfish over the WM and UWM forms. The greatest advantages to be gained in washing the mince are better

Table 4.—Mean and range of values for the more important components of the fatty acid profile (weight percent composition) of filleted weakfish harvested on a seasonal basis and stored at −18°C for 12 months.

Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range
March 1980	14:0	2.27	2.05 - 2.54	July 1980	14:0	2.23	2.11 - 2.53	December 1980	14.0	2.18	1.87 - 2.34
	16:0	23.68	22.74 - 24.39		16:0	27.12	26.34 - 28.47		16:0	24.88	24.17 - 26.13
	16:1	10.82	10.14 - 11.52		16:1	13.89	13.41 - 14.25		16:1	13.43	12.30 - 14.47
	18:0	6.31	5.58 - 6.91		18:0	6.95	6.59 - 7.31		18:0	6.30	6.06 - 6.60
	18:1ω9	19.64	19.64 - 20.39		18:1ω9	23.93	22.72 - 24.50		18:1ω9	22.49	21.81 - 23.80
	18:2ω6	1.08	0.94 - 1.23		18:2ω6	1.31	1.16 - 1.51		18:2ω6	1.33	0.72 - 1.88
	18:3ω3	0.78	0.59 - 1.03		18:3ω3	0.80	0.52 - 1.12		18:3ω3	0.88	0.55 - 1.41
	18:4ω3	1.80	1.65 - 1.98		18:4ω3	1.32	0.70 - 1.64		18:4ω3	1.57	0.34 - 2.59
	20:4ω6 / 20:3ω3	1.88	1.63 - 1.98		20:4ω6 / 20:3ω3	1.48	1.22 - 1.59		20:4ω6 / 20:3ω3	1.73	1.28 - 2.19
	20:5ω3	4.61	3.99 - 5.56		20:5ω3	2.28	2.06 - 2.47		20:5ω3	3.64	2.68 - 4.11
	22:5ω3	1.33	0.38 - 1.79		22:5ω3	1.13	0.99 - 1.25		22:5ω3	1.53	1.06 - 1.93
	22:6ω3	15.20	13.09 - 16.09		22:6ω3	8.28	7.45 - 9.17		22:6ω3	8.89	8.30 - 10.07
May 1980	14:0	2.49	2.24 - 2.71	September 1980	14:0	1.16	1.29 - 2.06	January 1981	14:0	2.33	2.05 - 2.66
	16:0	22.71	21.51 - 23.82		16:0	25.54	22.48 - 27.98		16:0	24.79	23.90 - 25.56
	16:1	10.38	9.96 - 10.57		16:1	9.57	7.64 - 12.24		16:1	12.65	12.13 - 13.42
	18:0	6.90	5.78 - 7.77		18:0	9.02	7.21 - 9.58		18:0	5.97	5.85 - 6.24
	18:1ω9	18.83	17.79 - 20.49		18:1ω9	18.12	15.97 - 21.21		18:1ω9	23.07	21.34 - 26.86
	18:2ω6	1.09	0.95 - 1.35		18:2ω6	1.20	0.68 - 1.81		18:2ω6	1.30	1.06 - 1.60
	18:3ω3	0.72	0.58 - 0.87		18:3ω3	0.49	0.28 - 0.68		18:3ω3	1.04	0.72 - 1.29
	18:4ω3	1.62	0.59 - 2.08		18:4ω3	1.14	0.92 - 1.45		18:4ω3	1.05	0.46 - 1.97
	20:4ω6 / 20:3ω3	1.60	1.40 - 1.83		20:4ω6 / 20:3ω3	2.53	2.32 - 2.90		20:4ω6 / 20:3ω3	1.42	1.11 - 1.98
	20:5ω3	4.84	4.37 - 5.23		20:5ω3	2.16	1.61 - 2.70		20:5ω3	4.03	3.57 - 4.50
	22:5ω3	1.84	1.60 - 1.96		22:5ω3	1.10	0.86 - 1.23		22:5ω3	1.44	1.27 - 1.54
	22:6ω3	15.70	14.77 - 16.61		22:6ω3	15.74	11.86 - 21.17		22:6ω3	10.44	10.17 - 10.58

Table 5.—Mean and range of values for the more important components of the fatty acid profile (weight percent composition) of washed minced weakfish harvested on a seasonal basis and stored at −18°C for 12 months.

Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range
March 1980	14:0	2.18	2.05 - 2.29	July 1980	14:0	2.23	2.06 - 2.18	December 1980	14.0	2.32	2.21 - 2.43
	16:0	24.62	23.75 - 25.50		16:0	27.66	27.28 - 28.27		16:0	24.45	23.44 - 25.05
	16:1	11.65	11.09 - 12.19		16:1	13.34	12.28 - 13.71		16:1	12.35	11.94 - 13.07
	18:0	6.34	6.03 - 6.59		18:0	7.17	6.70 - 7.57		18:0	6.21	5.76 - 6.53
	18:1ω9	22.11	21.52 - 22.80		18:1ω9	23.50	23.02 - 23.81		18:1ω9	23.76	20.42 - 29.70
	18:2ω6	1.04	0.89 - 1.26		18:2ω6	1.29	1.16 - 1.51		18:2ω6	1.28	0.89 - 1.47
	18:3ω3	0.76	0.51 - 1.11		18:3ω3	0.74	0.55 - 0.82		18:3ω3	1.08	0.89 - 1.43
	18:4ω3	1.63	1.53 - 1.78		18:4ω3	1.16	0.62 - 1.38		18:4ω3	1.40	0.36 - 2.21
	20:4ω6 / 20:3ω3	1.70	1.51 - 2.04		20:4ω6 / 20:3ω3	1.62	1.48 - 1.70		20:4ω6 / 20:3ω3	2.04	1.54 - 2.64
	20:5ω3	4.38	4.08 - 4.71		20:5ω3	2.37	2.26 - 2.61		20:5ω3	4.12	3.37 - 5.06
	22:5ω3	1.24	0.23 - 1.69		22:5ω3	1.10	0.96 - 1.18		22:5ω3	1.66	1.56 - 1.79
	22:6ω3	12.71	11.54 - 13.62		22:6ω3	8.92	7.98 - 9.66		22:6ω3	8.23	7.68 - 9.01
May 1980	14:0	2.82	2.68 - 2.89	September 1980	14:0	1.39	1.28 - 1.48	January 1981	14:0	2.78	2.37 - 2.67
	16:0	22.62	22.17 - 23.12		16:0	27.51	24.51 - 28.93		16:0	25.16	24.41 - 26.46
	16:1	10.99	10.58 - 11.21		16:1	11.86	10.79 - 12.50		16:1	12.41	12.00 - 13.38
	18:0	6.72	5.66 - 7.56		18:0	7.06	5.62 - 7.92		18:0	6.11	5.94 - 6.21
	18:1ω9	19.81	19.42 - 20.05		18:1ω9	21.50	19.91 - 22.92		18:1ω9	23.09	20.97 - 27.98
	18:2ω6	1.09	0.87 - 1.37		18:2ω6	0.99	0.59 - 1.20		18:2ω6	1.11	0.97 - 1.21
	18:3ω3	0.82	0.46 - 1.05		18:3ω3	0.65	0.48 - 0.77		18:3ω3	0.96	0.45 - 1.17
	18:4ω3	1.86	1.00 - 2.41		18:4ω3	1.35	1.15 - 1.67		18:4ω3	0.84	0.35 - 2.05
	20:4ω6 / 20:3ω3	1.65	1.35 - 1.80		20:4ω6 / 20:3ω3	2.66	2.23 - 3.68		20:4ω6 / 20:3ω3	1.54	1.22 - 2.11
	20:5ω3	5.01	4.56 - 5.40		20:5ω3	2.29	1.16 - 3.35		20:5ω3	4.43	4.04 - 4.95
	22:5ω3	1.89	1.82 - 1.96		22:5ω3	1.01	0.83 - 1.16		22:5ω3	1.51	1.39 - 1.57
	22:6ω3	12.81	12.03 - 13.85		22:6ω3	10.72	9.73 - 11.15		22:6ω3	10.29	9.76 - 10.73

storage stability and improved flavor, odor, and appearance. Minced weakfish provides a good source of protein for the human diet. The minced form (intermediate product) offers many opportunities for further processing.

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Table 6.—Mean and range of values for the more important components of the fatty acid profile (weight percent composition) of unwashed minced weakfish harvested on a seasonal basis and stored at −18°C for 12 months.

Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range	Date harvested	Fatty acid	Weight percent Mean	Weight percent Range
March 1980	14:0	2.23	2.02 - 2.36	July 1980	14:0	2.03	2.01 - 2.07	December 1980	14:0	2.28	2.19 - 2.39
	16:0	24.49	23.69 - 25.87		16:0	21.01	26.74 - 27.91		16:0	24.28	23.19 - 24.74
	16:1	11.63	10.92 - 12.06		16:1	13.07	12.76 - 13.42		16:1	12.35	11.57 - 13.57
	18:0	4.76	5.92 - 6.11		18:0	7.28	6.75 - 7.72		18:0	6.14	5.82 - 6.44
	18:1ω9	21.90	21.02 - 23.06		18:1ω9	23.91	23.32 - 24.26		18:1ω9	24.30	20.62 - 29.29
	18:2ω6	1.00	0.84 - 1.23		18:2ω6	1.40	1.18 - 1.62		18:2ω6	1.26	0.87 - 1.45
	18:3ω3	0.72	0.42 - 1.05		18:3ω3	0.80	0.74 - 0.90		18:3ω3	1.06	0.96 - 1.17
	18:4ω3	1.52	1.46 - 1.68		18:4ω3	1.30	0.78 - 1.49		18:4ω3	1.58	0.60 - 2.46
	18:4ω6 } 20:3ω3 }	1.77	1.63 - 2.01		20:4ω6 } 20:3ω3 }	1.56	1.31 - 1.75		20:4ω6 } 20:3ω3 }	2.09	1.45 - 2.92
	20:5ω3	4.64	4.28 - 5.47		20:5ω3	2.33	2.13 - 2.48		20:5ω3	3.84	3.15 - 5.17
	22:5ω3	1.30	0.30 - 1.82		22:5ω3	1.07	1.01 - 1.14		22:5ω3	1.54	1.43 - 1.76
	22:6ω3	13.27	12.85 - 14.67		22:6ω3	8.70	8.06 - 9.56		22:6ω3	7.63	7.00 - 8.33
May 1980	14:0	3.53	3.29 - 3.78	September 1980	14:0	1.51	1.48 - 1.56	January 1981	14:0	2.43	2.29 - 2.55
	16:0	22.79	22.45 - 23.26		16:0	28.66	27.95 - 29.87		16:0	25.25	24.65 - 26.33
	16:1	12.57	12.19 - 12.97		16:1	12.53	12.06 - 13.10		16:1	13.17	12.77 - 13.69
	18:0	6.59	5.88 - 6.94		18:0	7.11	6.38 - 7.48		18:0	6.16	6.07 - 6.31
	18:1ω9	20.49	20.09 - 20.84		18:1ω9	22.72	22.14 - 23.39		18:1ω9	22.37	21.73 - 23.18
	18:2ω6	1.19	0.98 - 1.32		18:2ω6	0.75	0.62 - 0.89		18:2ω6	1.19	1.07 - 1.31
	18:3ω3	0.78	0.49 - 0.94		18:3ω3	0.47	0.17 - 0.65		18:3ω3	0.90	0.62 - 1.16
	18:4ω3	1.90	1.41 - 2.14		18:4ω3	0.99	0.32 - 1.39		18:4ω3	0.87	0.45 - 1.82
	20:4ω6 } 20:3ω3 }	1.34	1.24 - 1.47		20:4ω6 } 20:3ω3 }	2.39	2.08 - 2.77		20:4ω6 } 20:3ω3 }	1.47	1.34 - 1.72
	20:5ω3	5.55	4.59 - 6.52		20:5ω3	2.04	1.80 - 2.26		20:5ω3	4.03	3.78 - 4.26
	22:5ω3	1.84	1.62 - 2.08		22:5ω3	1.02	0.93 - 1.12		22:5ω3	1.53	1.53 - 1.63
	22:6ω3	9.56	9.00 - 9.91		22:6ω3	11.40	10.24 - 12.55		22:6ω3	9.55	8.79 - 10.54

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Composition, Nutritive Value, and Sensory Attributes of Fish Sticks Prepared From Minced Fish Flesh Fortified With Textured Soy Proteins

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Introduction

Mechanically deboned fish flesh has become an important product to the seafood processing industry. The deboned flesh, which can be produced from either filleting waste or scaled, headed, and eviscerated carcasses of underutilized finfish species, is normally frozen into blocks which are then cut into fish sticks, fish portions, or other fabricated forms. The major problem with such products is the difference in texture between the natural flakiness of fish fillets compared with the more amorphous conditions of fabricated forms produced from minced flesh. To alleviate this, the industry formulated minced fish flesh with various additives such as hydrocolloids (Clark, 1982), polyphosphates (Brotsky and Swartz, 1982), gelling proteins (Decker et al., 1982), and soy proteins (Duersch, 1982) to create products with acceptable sensory attributes.

This research has determined the effect of texturized soy protein (TSP) on the composition and nutritive properties of fish sticks produced from minced fish flesh of different species. Our specific objectives were to: 1) Determine the relationship between moisture and TSP content in minced fish-TSP blends and 2) determine the proximate composition and nutritive value of minced fish-TSP sticks.

Experimental Procedures

Raw Materials

Minced flesh from walleye pollock, *Theraga chalcogramma*, and Atlantic cod, *Gadus morhua*, was supplied in frozen blocks by a commercial fish processing plant. The pollock flesh had been minced from headed and eviscerated carcasses, whereas the minced cod blocks were produced from deboning "V-cuts" and other trimmings from a filleting operation. No information on the time, location, and harvesting techniques for these two species was available from the supplier.

The underutilized species (spot, *Leiostomus xanthurus*, and Atlantic croaker, *Micropogonias undulatus*), caught incidentally during shrimping in the Gulf of Mexico (Meinke, 1974), were obtained from shrimp trawlers off the Texas coast. After being landed and separated from the shrimp, these fish were immediately iced and stored in ice chests overnight for processing the next day. Upon arrival at the Texas Agricultural Experiment Station, Texas A&M University, Corpus Christi, Tex., the fish were scaled, headed, eviscerated, and mechanically deboned as described by Finne et al. (1980). After deboning, the minced fish preparations were frozen as 1-pound blocks in wax-coated cardboard boxes using a plate freezer. The boxes were wrapped in plastic wrap and stored in a chest freezer at −30°C until the minced flesh was processed into fish sticks. All samples were in frozen storage less than 2 months before being processed.

The batter and breading materials used for coating the fish sticks were the same as those used commercially. Two textured soy flour samples (TSF I and TSF II) and a textured soy concentrate (TSC) were obtained from commercial sources.

Fish Stick Preparation

Frozen blocks of minced flesh were

ABSTRACT—The composition, nutritive value, and sensory attributes of fish sticks produced from minced fish flesh were investigated for various species fortified with textured soy protein. The use of a constant ratio of minced fish protein to textured soy protein (3.3:1) resulted in fish sticks with good sensory characteristics and nutritive value. Lysine and methionine were approximately 20 percent lower in soy-supplemented fish sticks compared with sticks prepared from pure minced fish flesh from the same species. All samples tested, except for walleye pollock and walleye pollock with textured soy protein, had significantly better protein efficiency ratios than casein.

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Table 1.—Proximate analyses of raw minced flesh preparations, TSP, batter, and breading material.

Item	Percent composition: Moisture	Protein	Oil	Ash	Crude fiber
Pollock	83.36	15.83	0.19	1.02	0
Cod	83.44	15.38	0.13	1.38	0
Croaker	78.65	17.10	3.76	0.98	0
Spot	76.56	17.34	5.84	1.02	0
TSF I	10.70	50.30	0.84	5.40	2.42
TSF II	9.88	51.23	0.32	6.36	2.13
TSC	8.25	66.03	0.12	6.58	3.74
Batter	10.49	4.75	1.24	2.53	0.24
Breading	7.06	10.13	1.84	5.40	0.11

Table 2.—Composition of minced flesh-TSP blends.

Fish-TSP blends	Percent minced flesh	TSP dry (%)	Hydration ratio (H_2O:TSP)	Protein ratio (Flesh:TSP)	Blend assays: Moisture (%)	Protein (%)
Pollock-TSF I	78	6.4	2.4:1	3.3:1	80	15.9
Cod-TSF I	78	6.4	2.4:1	3.3:1	80	15.7
Cod-TSF II	78	6.4	2.4:1	3.3:1	80	15.7
Cod-TSC	78	5.1	3.4:1	3.3:1	82	15.8
Croaker-TSF I	70.5	6.4	3.5:1	3.3:1	78	15.5

broken into small chunks and ground while semi-frozen, using a Hobart[1] food grinder, fitted with an end plate drilled with 5 mm holes. Hydrated crumbles of TSP were added to the ground flesh and mixed with a spatula. This minced fish-TSP mixture was passed through the Hobart grinder to insure proper blending and compressed into aluminum pans which were sealed and placed in a freezer at −30°C.

Fish sticks, measuring 8.9×2.2× 0.8 cm, were cut from the frozen blends using a band saw. The sticks were battered by immersion in a mix composed of five weights of dry batter and seven weights of water. Excess batter was allowed to drain from the sticks. The drained sticks were then put into a plastic bag containing excess breading material and shaken. This process covered the sticks with an even layer of breading material. The final battered and breaded sticks, which on a prefried basis contained 38-39 percent coating, were refrozen and kept in frozen storage until needed for sensory evaluations.

For sensory evaluations, the fish sticks were fried in vegetable oil at 190°C for 3-4 minutes (essentially to a uniform golden brown color). The fried sticks were served, while warm, to a trained, nine-member sensory panel and each member evaluated each sample for juiciness (9 = extremely juicy, 1 = extremely dry), flavor (9 = extremely desirable, 1 = extremely undesirable), texture (9 = extremely desirable, 1 = extremely undesirable), and overall satisfaction (9 = extremely desirable, 1 = extremely undesirable).

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Analytical Methods

Proximate and Amino Acid Composition

All proximate analyses were performed according to official AOAC methods (Horwitz, 1975). For determination of amino acids other than tryptophan and cystine, the samples were digested in 6 N hydrochloric acid in a stream of dry nitrogen. The amino acid composition of the hydrolysates was determined using a Beckman 150 C amino acid analyzer. Cystine was determined as cysteic acid by the method of Moore (1963) and tryptophan from barium hydroxide hydrolysates according to Slump and Schreuder (1969).

Protein Efficiency Ratios

Protein efficiency ratio (PER) assays were conducted by using 10 rats per sample over a 4-week growth period. The basal diet contained 80 percent starch, 10 percent combined corn oil plus fish oil supplied by the test samples, 5 percent Alphacel, 4 percent mineral mixture (USP XIV), and 1 percent vitamin mixture (General Biochemicals). Diets containing 10 percent protein (N×6.25) from finely ground sampling material or casein were prepared at the expense of the starch of the basal diet. Experimental PER values were calculated as grams of weight gained per gram of protein intake over a 28-day feeding period.

Statistical Analyses

All data were examined statistically by analysis of variance (ANOVA) and Duncan's Multiple Range Test.

Results and Discussion

The proximate composition of the various fish flesh preparations, soy samples, batter, and breading materials is shown in Table 1. The most likely explanation for the high moisture content of the pollock and cod samples compared with the moisture content of freshly prepared minced flesh from croaker and spot, is that these two species were captured in early spring close to spawning time.

To establish levels of TSP and moisture which would give fabricated sticks sensory attributes comparable to sticks prepared from frozen fish blocks, a number of initial screening experiments were conducted. During this phase, TSP content was varied from 1.6 to 13.2 percent of moisture-free TSP based on the final TSP-fish flesh blend. Hydration ratios, water to moisture free TSP, were also varied from 0:1 to 4.8:1. After reviewing the initial data, we decided to use a constant ratio between minced flesh protein and TSP protein of 3.3:1. By using this ratio and by varying the hydration to different moisture levels, it was possible to produce minced flesh-TSP blends with similar protein content but with moisture levels ranging from 77 to 82 percent.

The composition and sensory evaluations of the breaded fish sticks produced from the different TSP-fish blends are shown in Tables 2 and 3, respectively.

As Table 3 shows, there were some differences in the sensory perception of the different combinations. The cod-TSC and cod-TSF I sticks rated numerically higher in overall satisfaction. The low flavor score for the croaker blend could most likely be attributed to the high oil content of this species. Croaker had a fat content of 3.76 percent compared with only 0.19 and 0.13 percent for pollock and cod flesh.

Sensory evaluations of unsupplemented minced fish sticks are shown in Table 4. During this study, pollock and cod sticks were cut from both the original industrial blocks and from experimental blocks. The experimental blocks were prepared by first grinding chunks of the original fish blocks and then compressing the ground fish into pans. Sticks prepared from minced spot were severely downgraded with regard to flavor which again was most probably due to the high oil content.

Table 5 shows the proximate composition of the various TSP-minced fish sticks. As is evident, raw fish sticks formulated from different fish flesh-TSP combinations were very similar with regard to moisture content. Also, the fried sticks showed only small differences in moisture (50.7-53.6 percent), protein (12.7-14.1 percent), and oil (12.1-16.0 percent). The low moisture and high oil content for fried pollock-TSF I could be a reflection of a low water binding capacity of the minced pollock flesh. This was in agreement with the control fish sticks shown in Table 4 where pollock was given a low rating on the basis of both texture and overall satisfaction.

The essential amino acid distribution of the experimental minced flesh preparations is shown in Table 6. The second-column values are means of calculated amino acid contents for pollock-TSP, cod-TSP, and croaker-TSP battered and breaded fish sticks. The calculated amino acid values were based on means of duplicate essential amino acid assays of each ingredient. Only

Table 3.—Mean[1] sensory scores of fish sticks prepared with different TSP's and different minced fish flesh.

Fish and TSP	Juiciness	Flavor	Texture	Overall satisfaction
Pollock-TSF I	6.9^{ab}	6.5^{ab}	6.8^{ab}	5.9^{bc}
Cod-TSF I	6.6^{ab}	6.5^{ab}	6.8^{ab}	6.8^{a}
Cod-TSF II	6.5^{b}	6.0^{bc}	6.5^{b}	5.8^{c}
Cod-TSC	7.0^{a}	6.9^{a}	6.8^{ab}	6.9^{a}
Croaker-TSF I	6.2^{b}	5.8^{c}	7.0^{a}	5.9^{bc}

[1]Means with a common superscript letter in columns are not different ($P>0.05$).

Table 4.—Mean[1] sensory scores of control fish sticks.

Fish stick	Juiciness	Flavor	Texture	Overall satisfaction
Pollock[2]	5.5^{d}	5.5^{b}	4.8^{c}	5.2^{c}
Pollock[3]	6.7^{bc}	5.6^{b}	5.1^{b}	5.4^{bc}
Cod[2]	7.1^{ab}	7.4^{a}	7.3^{a}	7.3^{a}
Cod[3]	5.8^{cd}	5.9^{b}	5.7^{b}	5.9^{b}
Croaker[3]	7.8^{a}	7.2^{a}	7.3^{a}	7.2^{a}
Spot[3]	6.6^{bc}	4.3^{c}	7.1^{a}	5.1^{c}

[1]Means with a common superscript letter in columns are not different ($P>0.05$).
[2]Prepared from commercially processed blocks.
[3]Prepared from experimentally processed blocks.

Table 5.—Proximate composition of supplemented fish sticks.

Stick formulation[1]	Moisture: Raw	Moisture: Fried	Fried Protein: Wet basis	Fried Protein: Dry basis	Fried Oil: Wet basis	Fried Oil: Dry basis
	Proximate composition (%)					
Pollock-TSF I	65.2	50.7	12.7	25.8	16.0	32.4
Cod-TSF I	65.2	52.9	13.6	28.8	12.1	27.8
Cod-TSF II	65.2	53.6	13.0	28.0	12.6	27.2
Cod-TSC	66.1	52.4	13.5	28.4	12.9	27.0
Croaker-TSF I	63.9	51.1	14.1	28.8	14.2	29.0

[1]Ratio of flesh protein to TSP protein in blends = 3.3:1.

Table 6.—Essential amino acid composition of minced flesh and minced flesh-TSP battered and breaded sticks.

Amino acid	Minced flesh[2]	Sticks[3]	Ratio sticks: flesh
	Amino acid composition[1]		
Isoleucine	4.60 ± 0.37	4.48 ± 0.23	0.97
Leucine	8.02 ± 0.45	7.92 ± 0.31	0.99
Lysine	9.20 ± 0.10	7.43 ± 0.05	0.81
Phenylalanine	3.93 ± 0.27	4.22 ± 0.15	1.07
Methionine	3.12 ± 0.16	2.46 ± 0.11	0.79
Threonine	4.18 ± 0.14	3.88 ± 0.11	0.93
Tryptophan	1.24 ± 0.12	1.23 ± 0.11	0.99
Valine	5.05 ± 0.27	4.92 ± 0.17	0.99

[1]Grams of amino acid per 16 g of nitrogen.
[2]Amino acid assays are means of duplicate runs on each minced flesh: Pollock, cod, croaker, and spot.
[3]Amino acid values are means based on pollock-TSP, cod-TSP, and croaker-TSP sticks.

Table 7.—Protein efficiency ratio estimations[1].

Test sample	Protein intake (g)	Weight gain (g)	PER: Exptl.[2]	PER: Corr.[3]
Minced flesh				
Pollock	37.23 ± 2.76	122.7 ± 8.92	3.18 ± 0.13^{c}	2.50
Cod	38.88 ± 3.32	132.7 ± 10.23	3.34 ± 0.16^{ab}	2.69
Raw sticks				
Pollock-TSF I	37.11 ± 3.37	126.4 ± 12.75	3.41 ± 0.13^{a}	2.68
Cod-TSF I	37.65 ± 3.24	129.0 ± 13.13	3.43 ± 0.14^{a}	2.69
Croaker-TSF I	39.72 ± 2.93	137.0 ± 14.80	3.44 ± 0.16^{a}	2.71
Fried sticks				
Pollock-TSF I	35.31 ± 3.91	115.9 ± 13.23	3.28 ± 0.15^{bc}	2.58
Cod-TSF I	37.25 ± 2.70	126.3 ± 13.52	3.38 ± 0.15^{ab}	2.66
Casein standard	35.50 ± 2.72	112.9 ± 8.92	3.18 ± 0.16^{c}	2.50

[1]Data based on 10 rats per sample.
[2]Means with a common superscript letter are not different ($P>0.05$).
[3]Corrected to casein PER of 2.5.

lysine and methionine levels were appreciably lower in the TSP supplemented sticks compared with minced fish flesh. The concentrations of these two amino acids in supplemented fish sticks were approximately 80 percent of their content in unsupplemented sticks.

Table 7 shows the PER for raw minced flesh, raw supplemented sticks, fried supplemented sticks, and casein which was tested as a standard. All test samples except for the raw pollock and fried pollock-TSF I combination had significantly better PER values than casein.

This study has shown that the concept of using a constant ratio of minced flesh to textured soy protein of 3.3:1 is a reasonable approach to produce fish sticks of uniform composition, sensory attributes, and protein nutritive values.

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Processing Technologies and Their Effects on Microbiological Properties, Thermal Processing Efficiency, and Yield of Blue Crab

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Introduction

The fresh blue crab, *Callinectes sapidus*, industry must contend with a labor intensive, high quality, perishable product. Consequently, crab processors must strive to minimize production costs while maximizing production yields, product quality, and shelf life. Obviously, the ideal process would be one in which all these parameters were mutually compatible, or at least where no single parameter excluded another.

The blue crab industry's situation is unique in the animal food products processing industry. Most other products need only minimal handling after taking any step to reduce the bacterial population (i.e., cooking). However, in the blue crab industry the most intensive handling of the product occurs after cooking. To compound the problem, crabs are traditionally debacked and eviscerated after cooking, which presents an opportunity for microorganisms not destroyed during cooking to contaminate meat surfaces, pickers' hands, and utensils. This contamination, therefore, may result in crab meat that can periodically be found to exceed the bacteriological criteria established by state regulatory agencies, and as a consequence shorten the shelf life of the product.

ABSTRACT — Crabs which were debacked and eviscerated before boiling showed no bacteriological advantages when compared with the traditional methods of boiling (i.e., whole-boiled; whole-boiled, debacked, and washed). There was, however, an apparent time advantage: Debacked and eviscerated crabs achieved the same processing level of the traditional processes in 35 percent less time.

Total meat yields were unaffected by the type of process; however, when compared by type of meat, a difference was detected. Flake meat from whole-boiled crabs yielded significantly more ($\alpha = 0.05$) meat than did the two other processes. Apparently, the absence of the shell in the debacking processes exposed the flake-meat areas to more excessive desiccation during refrigerated storage (3.3°C) prior to removal of the meat.

Currently, the industry processes live crabs either with steam under pressure or in boiling water. Some states, such as Maryland, North Carolina, and Florida, have regulations which stipulate that "crabs shall be cooked only under steam pressure" (Maryland Department of Health and Mental Hygiene, 1977; North Carolina Department of Human Resources, 1977; Florida Department of Natural Resources, 1977). Other state regulations stipulate cold-point temperature minimums (i.e., the rules governing crab meat operations in North Carolina require that "crustacea shall be cooked under steam pressure until such time that the internal temperature of the center-most crustacean reaches 235°F" (North Carolina Department of Human Resources, 1977)). Other state laws are less stringent as they do not specify cooking requirements or simply state that "crabs shall be cooked so as to provide a sterile crab" (Texas State Department of Health, 1969).

Cooking live crabs in a steam retort is the most common method of processing (Phillips and Peeler, 1973). However, a major problem here is a lack of time and temperature uniformity among processors. Phillips and Peeler (1973) reported cook times ranging from 7 to 23 minutes at approximately 121°C (15 psi), and Ulmer (1964) reported cooking times from 3 to 20 minutes at 121°C. Furthermore, Dickerson and Berry (1976) reported steam temperatures ranging from 115.5°C to 121°C.

Another method commonly used in crab processing, particularly along the Gulf and South Atlantic coasts, is boiling. Although the temperature variations would not be as extreme as pressure steaming, there is considerable variation in the cooking times. Tinker and Learson (1972) reported cook times of 10-15 minutes while Ulmer (1964) reported times of 15-20 minutes.

Irrespective of method, cooking has three major effects. It 1) coagulates protein, which in turn loosens the meat from the shell to facilitate picking; 2) produces characteristic flavor of cooked crab meat; and 3) destroys many of the bacteria associated with the live crab (Ulmer, 1964).

This study explored blue crab processing methods and evaluated the impact of the processing variables on the microbiological character of the product, energy efficiency, and product yield.

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More specifically, we assessed the impact debacking and eviscerating the crab before processing had on these parameters as compared with the more traditional processing techniques. This new approach would bring blue crab processing in line with the sequence of events used in processing most other animal food products.

Materials and Methods

Raw Material

Crabs used in this study were obtained over 1.5 years and were harvested by potting and dredging. The crabs were harvested in the lower Chesapeake Bay and its estuaries and landed in Hampton, Va. The crabs were obtained from a local processor as they were being weighed off the boats. These crabs were then processed under the different experimental conditions on the same day they were harvested.

Processing

Crabs were brought back to the Virginia Polytechnic Institute and State University (VPI&SU) Food Science and Technology Department's Seafood Processing Research and Extension Unit Laboratory in Hampton, Va., for processing. There, the crabs were divided into groups for processing. The treatment processes follow.

Whole-Boiled, Debacked, and Washed

Whole crabs were cooked in boiling water for 10 minutes, removed, and placed in a sanitized plastic basket to cool at room temperature for 1 hour. Then they were debacked and eviscerated, and the visceral cavity was washed with a stream of water from a rubber hose with a jet nozzle. The crabs were then placed in another sanitized basket and stored at 3.3°C in a cooler overnight (about 12 hours).

Whole-Boiled

Whole crabs were cooked in boiling water for 10 minutes, removed, and placed in a sanitized plastic basket and stored at 3.3°C in a cooler overnight (about 12 hours).

Debacked, Eviscerated, and Boiled

Crabs were debacked and eviscerated live and then cooked in boiling water for 10 minutes. Crabs were then placed in a sanitized plastic basket and stored at 3.3°C in a cooler overnight (about 12 hours).

Steam Process

Whole crabs were cooked in a steam retort for 10 minutes at 121°C (15 pounds psi). The cooked crabs were placed in a sanitized plastic basket and stored at 3.3°C in a cooler overnight (about 12 hours).

Yield

After overnight cooling at 3.3°C, the crabs were weighed in the baskets and given to a professional crab picker for meat removal. The meat from each cook process was separated by type (flake, lump, claw) for yield determination.

Temperature Monitoring, and F_{250} Calculation

Temperatures of the cooking environments (water and steam), as well as the internal temperature of the crab's backfin muscle, were obtained with a Monitor Labs[1] Model 9300 twenty-channel temperature recorder coupled to copper constantan thermocouples.

The thermocouples were placed in the muscle of the swimming leg, by inserting the sensing end of the thermocouple through the outer membrane into the backfin muscle. The temperature recorder was programmed to print a temperature reading of the cooking vessel and crabs every 15 seconds. The data were used to calculate the F_{250} value of the various processes.

A computer program "on-line" at the VPI&SU computer center was used to calculate the F_{250} of the cooking process. The reference Z value used in the calculation was 18.

Microbiological Analysis

Microbiological analyses were performed on samples taken from the various cooking processes for the following: Aerobic plate count, (APC), coliform MPN, fecal coliform MPN, coagulase positive *Staphylococcus aureus*, *Vibrio parahaemolyticus*, and *Vibrio cholerae*. Due to the rigorous heating, we felt it necessary to test only samples taken from the steam process for APC, coliform MPN, and fecal coliform MPN. Procedures used in the performance of these tests were those outlined in the "Bacteriological Analytical Manual for Foods" (USFDA, 1978). Exception to these was in the analysis of APC's where surface plating procedures were used, and in the counting of *V. cholerae* where direct plating onto thiosulfate citrate bile salts sucrose agar (TCBS) was used after blending and diluting in alkaline peptone water. Additionally, suspect *V. parahaemolyticus* and *V. cholerae* colonies were picked off TCBS plates onto triple sugar iron agar slants (with NaCl for *V. parahaemolyticus* isolates); if typical reactions of the isolates were observed on these slants, then the organisms were said to be *V. parahaemolyticus*-like, or *V. cholerae*-like.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Results and Discussion

Heat penetration curves representative of the "whole-boiled" crabs and the "debacked, eviscerated, and boiled" crabs are presented in Figures 1 and 2, respectively. The results show more rapid heat penetration into crabs which have been debacked and eviscerated before cooking. This is due to the reduction in mass of the debacked and eviscerated crabs, which results in a more intimate contact of the crab muscle with the heating medium (boiling water) and therefore more rapid heat penetration into the muscle. The reduction in mass is significant and ranges from 23.1 percent to 36.3 percent of the total weight of the crabs.

The loss of a significant portion of the crab's mass before boiling implies that the process might be shortened and yet achieve a process equal to that of whole crabs boiled for a full 10 minutes.

The heat penetration data after 10 minutes of boiling whole crabs produced an F_{250} range of 0.0009 to

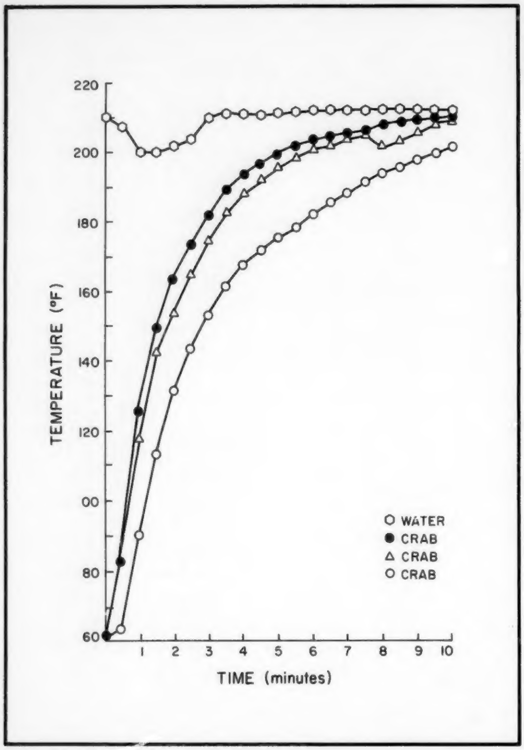

Figure 1.—Heat penetration curves for whole-boiled crabs.

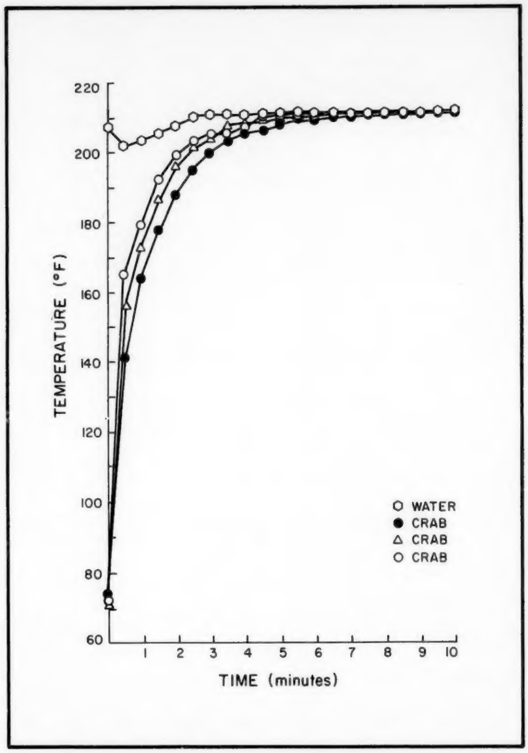

Figure 2.—Heat penetration curves for debacked, eviscerated, and boiled crabs.

0.0649. The average F_{250} was 0.0137, with a standard deviation of 0.0139. By comparison, the data for the "debacked, eviscerated, and boiled" crabs produced an F_{250} range of 0.0043 to 0.0602, with an average F_{250} of 0.0351 and standard deviation of 0.0124, thus indicating greater level of heating and less processing variability.

Assuming that the desired F_{250} value was 0.0137 (the average F_{250} for the "whole-boiled" crabs), this processing level was achieved in the debacked crabs in an average time of 6 minutes and 26 seconds. Hence, the possibility exists of shortening the processing time by about 35 percent.

A representative heat penetration curve for whole crabs steamed at 250°F for 10 minutes is shown in Figure 3. Steamed crabs obtain a considerably higher F_{250} than boiled crabs. The F_{250} for steamed crabs ranged from 3.8088 to 8.5150. The F_{250} of steamed crabs before initiation of the cook time was as great or greater than the final F_{250} values achieved in some of the boiled crabs.

A significant factor in potentially reducing the processing time of crabs, particularly whole vs. debacked crabs, is the microbiological quality of the finished product. Figures 4 and 5 are representative of the bacteriological profiles encountered during the processing stages of "whole-boiled", "debacked, eviscerated, boiled", and "whole-boiled, debacked, and washed" crabs. Although differences in the geometric means of the bacteriological indices were observed, no statistical significance, at $\alpha = 0.05$, was detected with any of the bacteriological indices at any stage of processing, irrespective of process. Though not statistically significant, the geometric means of the APC, coliform, and fecal coliform analyses were higher on the raw debacked crabs than on the raw whole crabs. This finding is contrary to what might be anticipated, since removal of the shell and a major portion of the viscera should reduce the total bacterial load. Under ideal conditions, the knives and hands of the people debacking the crabs would be sanitized between each crab. These practices were not used in this study, however, since it simulated commercial conditions where speed and volume are critical to commercial viability.

Debacking and eviscerating cooked

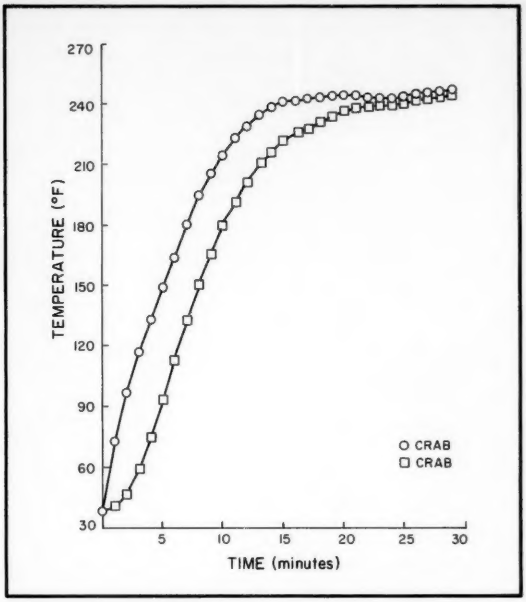

Figure 3.—Heat penetration curves for whole crabs steamed at 121°C.

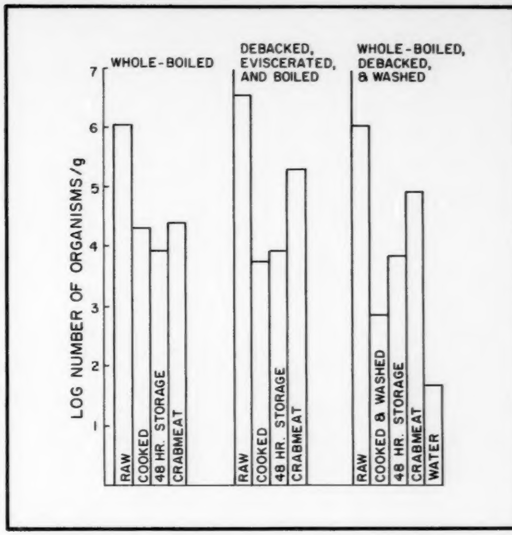

Figure 4.—Aerobic plate counts for whole-boiled; debacked, eviscerated, and boiled; and whole-boiled, debacked, and washed crabs (v = less than).

crabs followed by washing with running water did not improve the bacteriological quality of the product. This is in contrast to the suggestion by Ulmer et al. (1959); however, while the results of our study did not confirm the findings of those researchers, it also did not prove that washing the crabs would harm the bacteriological quality of the meat.

Our study also found it useful to run water through the hose for at least 5 minutes before washing the crabs to rinse away bacteria built up within the hose and/or nozzle while idle. During one study, bacterial numbers from a hose which had been idle for 7 days had an APC of 1.0×10^6 organisms/ml, and after 5 minutes of running water through the hose the numbers were reduced to 8.3×10^2. This was the exception rather than the rule, as the bacteriological quality of the water from the hose after 5 minutes of running was at all other times less than the standard of 500 organisms/ml (National Research Coun-

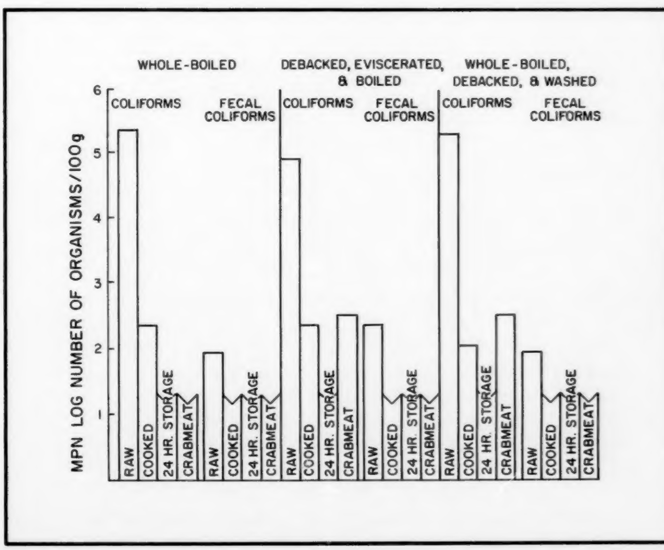

Figure 5.—Coliforms and fecal coliforms for whole-boiled; debacked, eviscerated, and boiled; and whole-boiled, debacked, and washed crabs (v = less than).

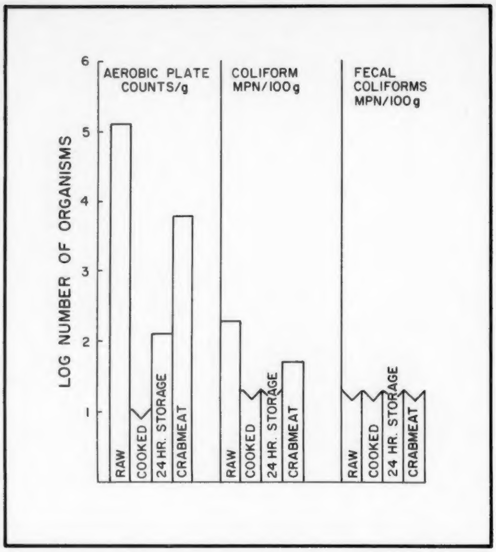

Figure 6.—Aerobic plate count, coliform, and fecal coliform data for whole crabs steamed at 121°C (v = less than).

cil, 1977). Nonetheless, it points out one possible source of contamination, especially if care is not taken to flush the hose after extended periods of nonuse. It is apparent from the APC and coliform data that the extensive handling by the crab picker during meat extraction contributes to the population of these bacteriological indicators. Although the fecal coliform levels were not significantly affected, the data for the APC's and coliforms corroborated work by other investigators (Phillips and Peeler, 1973; Lee and Pfeifer, 1975; Biediger, 1978; and Ward et al., 1976) that human hands contribute significantly to the bacteriological load of picked crab meat.

Representative bacteriological data generated from steaming whole crabs at 121°C for 10 minutes are presented in Figure 6. The bacterial numbers on the raw product are high, as are the bacterial numbers observed on the raw product used in the boiling studies (Fig. 4 and 5). However, the number of viable bacteria remaining on the cooked product is significantly lower. This is, no doubt, due to the amount of heat processing to which the steamed crabs are subjected.

That steamed crabs produced a cooked product of exceptional bacteriological quality immediately after processing is important, however, just as important are the increases in APC's after 24 hours of storage in a 3.3°C cooler. The increases probably resulted from either post-processing contamination or perhaps repair of injured bacteria. Moreover, the subsequent increases in bacterial numbers on the picked meat are once again evidence of human handling as the primary source of bacterial contamination.

Data obtained for *V. parahaemolyticus*-like organisms or *V. cholerae*-like organisms produced no significant or consistent pattern of isolation. Coagulase-positive isolates of *S. aureus* were obtained from picked meat only once when it was counted at a level of 13,300/g. On every other occasion the same crab picker had been used to minimize variability in meat yield. In this instance, however, the regular picker was absent and another picker was used. It can be surmised that the regular picker either was not a carrier of *S. aureus* or she practiced very effective sanitary procedures in picking and handling the crab meat. By comparison, the substitute picker may have been a carrier and/or may not have been as cautious in product handling.

The total picked meat yield between the three boiling processes produced no significant differences ($\alpha = 0.05$). However, when meat types (backfin, flake, and claw) were compared, a significant yield difference was detected. The "whole-boiled" flake meat produced a significantly higher yield than did the flake meat produced by "debacking, eviscerating, and boiling" or by "whole-boiling, debacking, and washing". The reason for this phenomenon can possibly be explained on the basis of moisture content (Table 1).

Table 1.—Moisture content of boiled crabs as affected by process and storage.

Process	Percent moisture after process	Percent moisture after 24 hours at 3.3°C
Whole-boiled	82.0	80.9
Debacked, eviscerated, and boiled	82.4	77.6
Whole-boiled, debacked, eviscerated, and washed	82.6	79.0

Apparently, the shell, which remains on the "whole-boiled" crab, acts as an effective barrier to excessive desiccation of the crab while in storage. Furthermore, since this study indicated that flake meat from "whole-boiled" and steamed crabs produced a higher yield than did the flake meat from the other two boiling processes, it should be noted that the area from which the flake meat is picked has the highest degree of exposure on the debacked and eviscerated crabs, thus further contributing to the moisture loss from those areas.

We observed several differences between the data from the steam cooked crabs vs. those obtained from the various boiling processes. For instance,

"whole-boiled" crabs yielded significantly more total meat than did steamed crabs ($\alpha = 0.05$); however, no significant differences were observed in total meat yield when steamed crabs were compared with "debacked, eviscerated, and boiled" crabs and with "whole-boiled, debacked, and washed" crabs. Additionally, the "whole-boiled" backfin produced a significantly greater yield than did steamed crabs. Conversely, steamed crabs yielded significantly more flake meat than the "debacked, eviscerated, and boiled" crabs.

Summary

The method used to process blue crabs does not appear to significantly impact the quality of the picked meat under the conditions which currently prevail in most processing plants. However, it is apparent that steaming crabs under pressure produces an initial cooked product which is bacteriologically superior to those produced by boiling. Nonetheless, since most crab meat is hand picked, any process designed to improve the bacteriological character of the product will be no better than the personal hygiene of the crab picker.

Processing of "debacked, eviscerated, and boiled" crabs does offer the possibility of shortening the cooking time of these crabs by as much as 35 percent over that of "whole-boiled" crabs, hence saving energy for the processor. Furthermore, although not quantitated in this research, energy can also be saved in the cooling of debacked crabs during refrigerated storage. However, the savings generated in cooking debacked crabs may be effectively lost due to the reduced flake meat yield of the crabs held overnight in refrigerated storage.

These findings are important for many in the crab industry who are processing crabs by whole boiling, then debacking, washing, and refrigerating overnight, insofar as they may be losing yield without the countering benefit of energy savings. To realize the highest picked-meat yield, this study demonstrated the "whole-boiled" crabs with the shells remaining intact during refrigeration prior to picking resulted in the highest yield, because the shell helped protect the meat surfaces from excessive desiccation.

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Incidental Catch of Marine Mammals by Foreign Fishing Vessels, 1978-81

THOMAS R. LOUGHLIN, LEWIS CONSIGLIERI, ROBERT L. DELONG, and ANN T. ACTOR

Introduction

Passage of the Marine Mammal Protection Act (MMPA) of 1972 established a moratorium on the taking of marine mammals. Exceptions to the moratorium included the incidental taking of marine mammals in commercial fishing operations for which a General Permit system was established by the U.S. National Marine Fisheries Service (NMFS). Amendments to the MMPA in 1981 authorized the Secretary of Commerce to waive the permit requirement in certain instances. However, General Permits allowing the incidental take of marine mammals have been issued by the NMFS to domestic fishermen since 1974 and to foreign fishermen, under jurisdiction of the Magnuson Fishery Conservation and Management Act (MFCMA) of 1976, since 1977. The issuance of General Permits to foreign vessels was restricted to those operating within the U.S. 200-mile fishery conservation zone (FCZ). The incidental taking of marine mammals produces the need to estimate regularly the number and location of marine mammals incidentally caught in the course of commercial fishing operations, with the objective of determining the overall impact of this take on marine mammal stocks.

ABSTRACT—U.S. fishery observers were placed aboard 10 percent of the foreign fishing vessels in the U.S. fishery conservation zone in the northeastern north Pacific Ocean and Bering Sea during 1978-81 and collected data on marine mammals incidentally taken by the vessels. Of the total 298 marine mammals observed incidentally taken, 81 were released alive and 217 were dead. Species taken in low numbers included northern fur seal, harbor seal, northern elephant seal, ribbon seal, walrus, and Dall's porpoise. Northern sea lions were the prevalent species taken and accounted for 90 percent of the total. Tooth samples from 78 dead northern sea lions yielded a range of ages for males and females of between 1 and 16 years, most being 9 years or less. The total estimated annual sea lion take between 1978 and 1981 averaged 724 animals. Thus the total sea lion population of well over 200,000 animals was most likely not significantly affected. The majority of the take occurs between late autumn and early spring, a period when sea lions are not concentrated on rookeries. Japan and the Soviet Union accounted for the majority of incidentally caught marine mammals.

Since implementation of the MFCMA, the United States has placed fishery observers aboard foreign trawl and long-line fishing vessels in the FCZ to collect data which are used by the United States to estimate the foreign commercial catch, provide information on the various stocks of fish, and report compliance with U.S. fishing regulations (French et al., 1982). For example, in 1977 and 1978 combined, 122 fisheries observers sampled caught fish on 128 foreign vessels in the eastern Bering Sea and Aleutian Islands region (Nelson et al., 1981). Observer coverage averaged 10 percent between 1978 and 1981 in the area covered in this paper. A description of the sampling methods used in different regions by U.S. observers may be found in Nelson et al. (1981), Wall et al. (1981), and French et al. (1981).

Although the primary objective of fishery observers was to collect fishery data, they have also collected data on marine mammals caught incidental to fishing operations, including species, number observed caught, sex, morphological measurements, location, and, since 1979, the collection of canine teeth when appropriate.

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All foreign vessels fishing within the FCZ are required to have a General Permit and, as a stipulation of the permit, to report all marine mammals caught while in the FCZ. The reporting by vessels may not be reliable, however, since there is no assurance that they are reporting all the animals caught by them. The identification of animals caught and reported may also be subject to question since the ships' personnel are not trained to identify marine mammals properly. Also, not all foreign vessels have observers on board, which reduces the number of observer-reported animals in proportion to the total number of incidentally taken marine mammals. Reports by U.S. observers onboard foreign vessels are more reliable, but these include only the animals actually seen by the individual observer and consequently do not include all of the animals taken.

Fishery observers have been placed on foreign vessels for many years and have reported the incidental take of marine mammals since 1972; however, the methods used for collecting data and the reporting requirements have progressively improved. The more rigorous reporting scheme now in use is partly due to requirements in the MMPA and MFCMA, stipulating that the Federal Government manage fishery stocks and marine mammal stocks together, resulting in the need to report and record accurately the incidental take of marine

mammals. In the observer scheme used prior to the MFCMA, observers reported some, but not all, marine mammals taken in hauls observed by crew members. Most fish sampling was done in the hold where marine mammals might not be seen, and not all marine mammals taken and observed by fishery observers were reported. During the period 1972-76, about 800 marine mammal mortalities (mostly sea lions) were estimated annually from fishery observer reports, similar to the average take for the period 1978-81. But, because of the loose reporting requirements during the former period, the total annual estimated take is regarded by us as equivocal and underestimated. In our view the former data were too rough to provide accurate estimates, and the present observer scheme provides a better indication of the incidental take of marine mammals in the foreign fishery.

The purpose of this paper is to summarize the incidental take of marine mammals as reported by U.S. observers on foreign fishing vessels in the northeastern north Pacific Ocean and eastern Bering Sea FCZ from 1978 to 1981. Marine mammals reported by U.S. observers on foreign vessels which were part of a joint venture are not included here since those animals were caught by U.S. fishermen. We include a description of the species caught, their sex, number, age (when available), location, the type of fishery involved, and nationality of the vessel in which the take occurred.

Marine Mammal Species Summary

During the period 1978-81 a total of 298 marine mammals were observed by U.S. fisheries observers incidentally taken by foreign vessels fishing within the north Pacific Ocean and Bering Sea FCZ (Table 1). Of these, 81 were caught and released alive; the remaining 217 either died as a result of the fishing operation or were dead when taken by the fishery. Northern (Steller) sea lions, *Eumetopias jubatus*, were the prevalent species taken, representing 90 percent (268 animals) of those caught. Northern fur seals, *Callorhinus ursinus*, were the next most abundant pinniped caught, representing 3 percent of the total (9 animals). Infrequently, harbor seals, *Phoca vitulina*; ribbon seals, *Phoca fasciata*; northern elephant seals, *Mirounga angustirostris*; and walrus, *Odobenus rosmarus*, were caught, but in very low numbers (Table 1). Six Dall's porpoise, *Phocoenoides dalli*, were caught and were the prevalent cetacean identified; eight unidentified cetaceans were also caught.

The northern sea lion's breeding range is centered in the Aleutian Islands and Gulf of Alaska (Calkins and Pitcher, 1982; Loughlin et al., in press). Not surprisingly, in those areas of the southeastern Bering Sea and Gulf of Alaska where intense foreign commercial fishing occurs, high incidental take of sea lions is prevalent (Fig. 1). Another reason for the high incidental take of sea lions, which unlike other marine mammals that tend to shun fishing vessels, is their propensity to follow fishing vessels to feed on fish discarded during processing or to interfere with the net and other gear during the fishing operation. The occurrence of sea lions near fishing vessels far out at sea seems to have been observed only since the expansion of foreign commercial fishing activity in the north Pacific Ocean and Bering Sea, although sea lions were regularly seen on halibut grounds when vessels were present[1]. Few large groups of sea lions were seen further than 10-15 miles offshore during extensive pelagic fur seal studies in the 1950's and 1960's (Fiscus and Baines, 1966).

Since 1979, fishery observers have opportunistically collected sea lion teeth which were given to us for age determination by counting dental annuli (Fiscus, 1961; Spalding, 1964). The reader should be cautioned that the data based on collected teeth may be biased, since not all animals caught and killed are represented in the tooth samples, and smaller animals (young and females) may be overrepresented because observers and vessel crews may prefer to sample the smaller animals that are easier to handle on deck. In 1979, teeth from 26 sea lions were collected by fishery observers representing 82 percent of the sea lions seen and which died that year in the foreign commercial fishery (Table 1). In 1980, teeth were collected from 37 sea lions, representing 80 percent of those that died; and in 1981 teeth were collected from 15 sea lions, representing 48 percent of those that died. Of the 26 sea lions collected in 1979, 12 were females; in 1980, 18 of 37 were females; and in 1981 6 of 15 were females. The age of all males and females ranged from 1 year to 16 years, with 92 percent aged 9 years or younger.

Male sea lions in the Gulf of Alaska

Table 1.—Summary of incidentally taken marine mammal species observed by U.S. fisheries observers on foreign vessels in the northeastern North Pacific Ocean and eastern Bering Sea fishery conservation zone, 1978-81. Numbers represent only animals from hauls observed by the fishery observer on 10 percent of the foreign vessels.

Species	1978	1979	1980	1981	Total
Northern sea lion, *Eumetopias jubatus*	117(38)*	57(24)	51(5)	43(12)	268
Northern fur seal, *Callorhinus ursinus*	3	1	3	1	8
Harbor seal, *Phoca vitulina*		1			1
Northern elephant seal, *Mirounga angustirostris*		1			1
Ribbon seal, *Phoca fasciata*	1				1
Walrus, *Odobenus rosmarus*	1	1	1		3
Unidentified pinniped		2			2
Dall's porpoise, *Phocoenoides dalli*	1(1)	4		1	6
Unidentified cetacean	3	3		2	8
Total	126(39)	70(24)	55(5)	47(12)	298

*Totals include animals found dead in catch, decomposed in catch, and released alive (in parentheses).

[1]C. Fiscus, formerly of the National Marine Mammal Laboratory, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115, pers. commun. 1982.

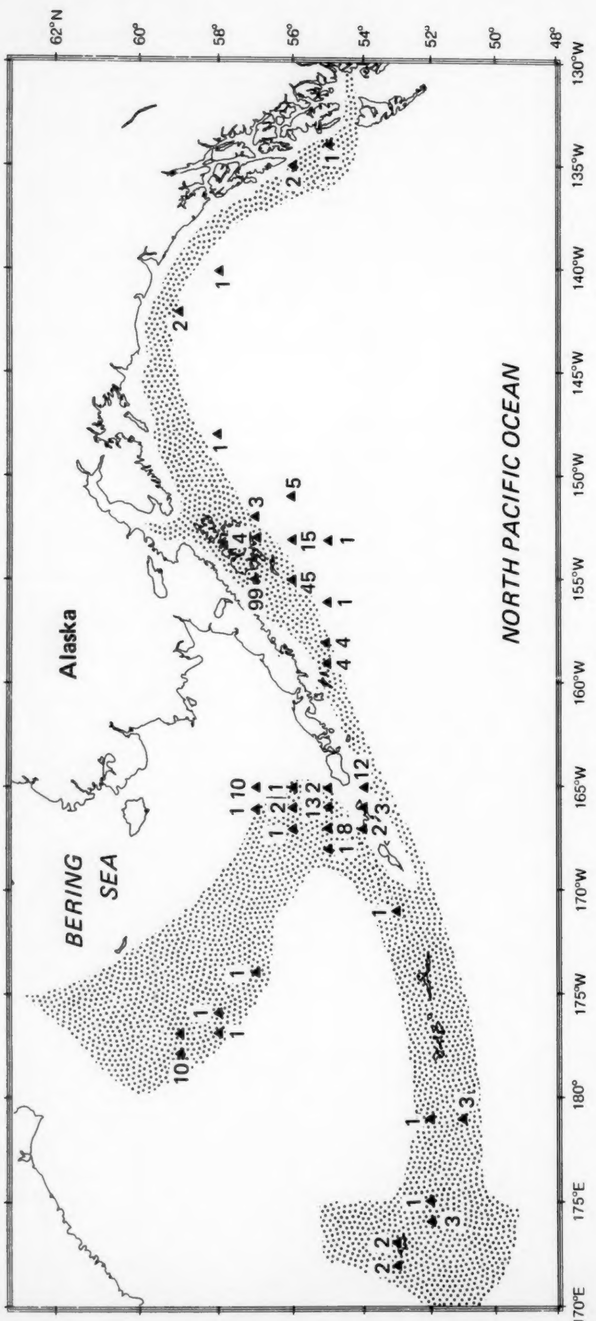

Figure 1.—Northeastern north Pacific Ocean and eastern Bering Sea showing location and number of incidentally caught marine mammals in relation to areas of heaviest commercial fishing by foreign vessels (shaded area).

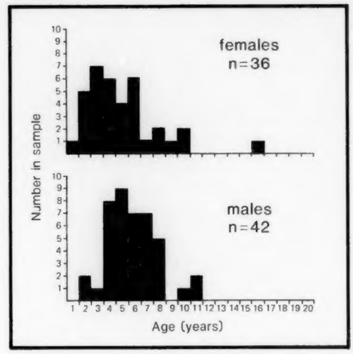

Figure 2.—Age structure of northern sea lions caught incidental to foreign fishing in the northeastern north Pacific Ocean and eastern Bering Sea, 1979-81. Only animals that had teeth removed are represented.

mature between 5 and 7 years of age, and most are able to obtain and defend territories between 9 and 13 years of age (Thorsteinson and Lensink, 1962; Pitcher and Calkins, 1981). Of the 42 males that we aged for the years 1979-81, 11 were less than 5 years of age and probably not sexually mature; 3 were 10 years of age or older and were probably old enough to obtain and defend territories; the remaining 28 ranged from 5 to 8 years of age and were probably sexually mature but too young or small to be considered territorial (Fig. 2). Therefore, of the dead male sea lions reported by observers on foreign commercial fishing vessels during 1979-81 which had teeth removed for aging, only three were probably actively reproducing males, and the others were subadult or newly matured males and not active participants in the reproducing population.

The average age of first ovulation for female sea lions in the Gulf of Alaska was 4.6 ± 0.8 years and the average age for first pregnancy was 4.9 ± 1.2 years (Pitcher and Calkins, 1981). Of the 36 incidentally caught females that we aged for the years 1979-81, 13 were 1-3 years of age. The remaining 23 ranged from 4 to 16 years of age and probably represented sexually mature animals; all but one of these were between 4 and 10 years of age. In the Gulf of Alaska, Pitcher and

Calkins (1981) found the pregnancy rate for 4-year-olds to be 81.3 percent; for 5-year-olds, 80 percent; and for 6- to 15-year-olds, 100 percent. Therefore, it seems likely that of the females taken in the foreign commercial fishery in 1979-81, only 13 (35 percent) were sexually immature while 23 (65 percent) were sexually mature. However, significant adverse impacts on the sea lion population as a whole are unlikely, given the low estimated total incidental annual take (see below). Recent minimum population estimates range from 240,000 to 290,000 individuals worldwide, of which all but about 35,000 are in Alaskan and Canadian waters (Loughlin et al., in press). However, small local populations may suffer from the loss of sexually mature female animals.

The incidental take of all marine mammals, especially sea lions, occurs primarily from late summer through early spring. Of those taken incidental to foreign fishing between 1978 and 1981, 77 percent were caught between September and April (Fig. 3). The highest monthly catch occurred in October when 12 percent of the total were taken. Only 3 percent and 4 percent of the total take were reported in May and June, respectively. A trend exists towards an inverse relationship by month between the number of sea lions incidentally taken in the foreign fishery and the number of foreign vessels in the FCZ. For the Gulf of Alaska and Bering Sea, where most of the sea lions were taken (Fig. 1), the highest number of vessels occurs during spring and summer (Fig. 3). The monthly distribution of incidental take is apparently not related directly to the number of vessels present but is more likely an indication of the number of sea lions in the area. The peak breeding season for sea lions is during June (Pitcher and Calkins, 1981) and most of the animals are on rookeries or feeding near shore during spring. The number of animals at sea is thereby reduced, lowering the likelihood of incidental take in the foreign fishery.

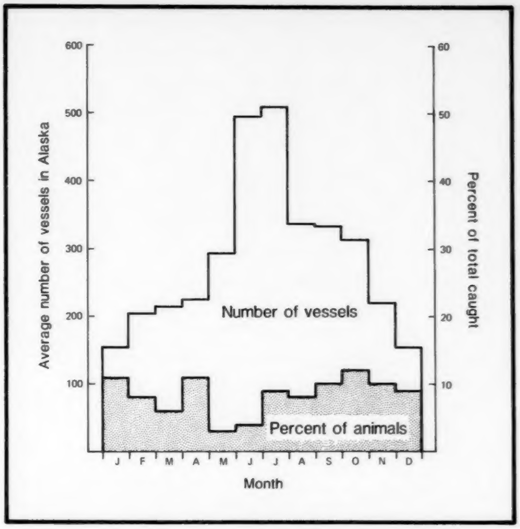

Figure 3.—Percent of sea lions taken observed by fishery observers on foreign fishing vessels by month in the northeastern north Pacific Ocean and eastern Bering Sea and the average number of foreign vessels fishing off Alaska, 1978-81. The number of vessels was obtained by the Enforcement Division, NMFS Alaska Regional Office, Juneau.

Table 2.—Number of incidentally taken marine mammal species observed by U.S. fisheries observers onboard foreign fishing vessels in the northeastern North Pacific Ocean and eastern Bering Sea FCZ by nation, 1978-81.

Species	Japan	South Korea	Poland	U.S.S.R.	West Germany	Total
Northern sea lion	197	13	4	44	10	268
Northern fur seal	4	1		3		8
Harbor seal		1				1
Northern elephant seal	1					1
Ribbon seal	1					1
Walrus	2	1				3
Unidentified pinniped	2					2
Dall's porpoise	1		2	3		6
Unidentified cetacean	4	1	1	2		8
Total observed take	212	17	7	52	10	298
Extrapolated total kill (summed from Table 3)	1,881	130	42	755	89	2,897

Foreign Vessel Summary

Vessels from Japan, South Korea, Poland, West Germany, and the Soviet Union accounted for all of the U.S. observer-reported marine mammals incidentally taken during 1978-81 (Table 2). Japanese vessels took a reported 212 marine mammals, of which 197 were northern sea lions with the other species taken ranging from 1 to 4 animals. Soviet vessels accounted for the second highest recorded take, totaling 52 animals of which 44 were sea lions. South Korean vessels took only 17, 13 of which were sea lions; West German vessels took 10 sea lions; and Polish vessels accounted for 4 sea lions, 2 Dall's porpoise, and 1 cetacean.

That vessels from Japan and the Soviet Union[2] account for most of the

[2]The Soviet Union has not been given a groundfish allocation in the FCZ since 1980.

Table 3.—Number of marine mammals observed caught by fishery observers per metric ton (t) of groundfish by nation, 1978-81, and an extrapolation of the number expected to be killed in the fishery.

Year and nation	Groundfish: Total t caught (A)	Groundfish: Observed t caught (and as % of A) (B)	Marine mammals: No. observed dead in catch[2] (C)	Marine mammals: No. per observed t caught ($\times 10^{-4}$) (C/B)	Marine mammals: Total number expected dead (A·C/B)
1978					
S. Korea	103,356	4,538 (4.4)	2	4.4	46
USSR	227,221	18,879 (8.3)	4	2.1	48
Japan	1,123,179	58,822 (5.2)	63	10.7	1,203
				Total	1,297
1979					
S. Korea	126,626	13,290 (10.5)	1	0.7	10
USSR	250,521	26,867 (10.7)	26	9.7	243
Japan	1,085,429	57,289 (5.3)	12	2.1	227
				Total	480
1980					
S. Korea	210,277	16,950 (8.1)	6	3.5	74
USSR	85,641	2,766 (3.2)	15	54.2	464
Japan	1,161,511	93,354 (8.0)	27	2.9	336
				Total	874
1981					
Poland	160,301	22,676 (14.2)	6	2.6	42
Japan	1,148,983	160,190 (13.9)	16	1.0	115
W. Germany	11,872	1,331 (11.2)	10	75.1	89
				Total	246

[1]Bering Sea-Aleutian Islands, Gulf of Alaska, and east Pacific coast.
[2]Does not include "decomposed in catch."

marine mammals incidentally taken in the foreign fishery is not surprising, since their vessels also account for most of the foreign fishing effort in the north Pacific Ocean and Bering Sea. In our study area, Japan has had more vessels, more vessel fishing days, was allocated more groundfish, and has caught more fish than any other nation (Bakkala et al., 1979; French et al., 1982). The Soviet Union was second in most categories while Poland, West Germany, and South Korea had smaller efforts.

The primary fishery in which marine mammals were taken incidental to fishing was the eastern Bering Sea/Gulf of Alaska groundfish fishery. Bottom and midwater trawling by stern trawlers, pair trawlers, and Danish seiners were the most common types of gear used. Seines are flat nets fitted with floats on top and weights on the bottom and are pulled by one end to encircle fish. Danish seiners are used primarily below the surface to encircle fish near the bottom or at midwater depths. Trawl nets are towed along the bottom or at midwater; the cone-shaped nets are held open at the mouth by large steel doors (otter boards) (Royce, 1972; Browning, 1980).

Trawl gear is the predominant type used by the foreign groundfish fleet in the north Pacific Ocean and Bering Sea (Bakkala et al., 1979) and accounts for most marine mammal deaths in the fishery. Presumably the marine mammals, most frequently northern sea lions, drown after they enter the net during its ascent or descent to consume the entrapped fish. Uncommonly, animals already dead and lying on the bottom were scooped up by the net and were recorded as incidentally taken animals. Smaller animals, such as some immature sea lions, harbor seals, and northern fur seals are incidentally caught in salmon and herring gill nets. Mature northern sea lions and other large marine mammals are able to break free from such frail gear and may thus cause substantial damage to the gear. Longline fisheries account for only one or two incidentally taken animals a year, although northern sea lions and killer whales, *Orcinus orca*, interact with the fishery by eating large numbers of hooked fish[3].

[3]MMPA General Permit application to National Marine Fisheries Service by North Pacific Longline Gill Net Association, 1983.

Table 3 presents an index of marine mammals taken per metric ton (t) of groundfish caught by country and an estimate of the total number of animals killed based on an extrapolation from those observed dead. The estimate of groundfish caught is based on data collected by the Northwest and Alaska Fisheries Center, NMFS. Of interest is the low number of animals incidentally killed per observed metric ton of caught fish and the variability each year in the estimated total mortalities. The amount of fish taken per haul will vary depending on the type of gear used, density and distribution of the fish, and duration of the tow; but the likelihood of killing one or more marine mammals in about every 10^4 t of fish implies that they are rarely encountered dead in the net during fishing operations. The total number of marine mammals expected to die in the foreign fishery each year ranges from 1,297 for 1978 to 246 for 1981, with an average of 724 for 1978-81. There is a declining trend in the number of animals expected to die, but the trend is not uniform. The expected marine mammal catch varies from year to year, although fishing effort occurs (as expressed in days fishing/month/country) in the same approximate location and is relatively constant. Comparison of the yearly total of metric tons of fish caught (which of course reflects the total allowable-take quota authorized under the MFCMA) supports this finding.

EMIS Recording System

As mentioned above, all foreign vessels fishing within the U.S. FCZ are required to report all marine mammals incidentally caught during fishing operations. The take is reported by the vessel operator to the nearest NMFS Regional Office, usually the NMFS Alaska Regional Office in Juneau. The incidental catch data are then entered into a computer program termed EMIS (Enforcement Management Information System) for subsequent storage and analysis. This system has been operational since 1979.

We compared the EMIS records for the period 1979-81 of incidentally

Table 4.—Numbers of incidentally caught marine mammals, 1979-81, as reported by foreign vessel operators compared to the take reported by U.S. fishery observers and the total kill extrapolated from fishery observer reports.

Type of marine mammal	1979	1980	1981	Total
Otariids	45	29	156	230
Northern sea lions	24	18	29	71
Northern fur seals	2	2		4
Other pinnipeds	5	8	9	22
Cetaceans	2	1	3	6
Total	78	58	197	333
U.S. observer totals	70	55	47	172
Extrapolated kill totals	480	874	246	1,600

caught marine mammals reported by the vessels with the records of those reported by fishery observers (Table 4). For 1979, 78 animals were reported by vessel operators, 58 in 1980, and 197 in 1981. In comparison, fishery observers reported 70, 55, and 47, respectively. The total vessel reported take for the 3 years was 333 animals versus 172 reported for the same time period by fishery observers. Northern sea lions and otariids (a general category used by vessels to report eared seals, but usually representing northern sea lions and only infrequently northern fur seals) were the prominent species reported taken by the vessels. Other pinnipeds and cetaceans were also reported taken, but in low numbers.

The takes reported by vessels and by fishery observers for 1979 and 1980 were very similar, suggesting that vessel operators were more likely to report only those animals that the fishery observer reported. That only 10 percent of the vessels had fishery observers aboard suggests that 90 percent of the vessels did not report their incidentally taken marine mammals in 1979 and 1980. But this suggestion is misleading. We compared the reports by vessel operators with those of the fishery observers for 1980 and found that of the 16 animals taken and reported by fishery observers on Soviet vessels, none were reported by vessel operators (they were not on the EMIS data base). Only two animals taken by the Soviets were on the EMIS data system. For South Korean vessels, all 6 animals taken that were reported by observers, plus 12 others reported by the vessel operators, were on the EMIS data system. The reported take by Japanese vessels is more complicated: About 33 percent of the observer-reported takes were reported by the vessel operator. Coincidentally, Japanese vessel operators reported 34 animals taken, the same number as the observers. There appears to be no consistency by year in reporting by country or vessel, whether or not a fishery observer is on board. The reported take in 1981 of 197 animals by all foreign vessel operators (Table 4) suggests that operators were more inclined to report incidentally caught marine mammals, even if a fishery observer was not on board, although the number is still below our total projected marine mammal catch of 246 animals for 1981.

It is obvious that neither reporting system is ideal and that improvements are needed in both. The precision of the estimated total kill by the fishery-observer reporting scheme could be improved by increasing the number of observers and the percent of coverage. Amendments to the MFCMA in 1980 mandated 100 percent coverage. To achieve that, an observer fund was established which the foreign nations pay into to cover observer costs. As a result, coverage in 1982 was increased to 30 percent and planned coverage for 1983 is near 50 percent. Reporting by vessels seems to be improving as more effort is placed on obtaining the needed information, but there is no method currently available to ensure that all marine mammals that are caught are reported or that those reported are correctly identified. We believe that the best approach for estimating the annual take of incidentally caught marine mammals in the future is to rely primarily on the fishery observer reporting method and to regard the extrapolated total kills as minimum estimates. Our reliance on this method is based on the expected future increase in coverage by fishery observers, the reliability of their observations, and the suspicion that foreign vessel operators do not report incidentally caught marine mammals when fishery observers are not on board.

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An Economic Appraisal of Sail-Assisted Commercial Fishing Vessels in Hawaiian Waters

KARL C. SAMPLES

Introduction

During the past decade, commercial fishermen in the United States experienced a rapid escalation in prices paid for motor fuel. This has revived an interest in using fishing boats propelled by a combination of sail and motor power.

It remains to be shown, however, whether investment in such vessels is economically justified as a means of reducing total operating costs associated with fishing. Positive indications of the cost-effectiveness of sail-assisted fishing vessels are evident in studies conducted by Shortall (1981) and Sorensen-Viale (1981). On the other hand, inquiries into the projected financial performance of sail-assisted cargo vessels have produced conflicting findings regarding their investment feasibility (Bergeson et al., 1981; Couper, 1979; Woodward et al., 1975).

ABSTRACT—This article investigates the projected cost-effectiveness of procuring and operating two sizes of multipurpose sail-assisted vessels for commercial fishing in Hawaiian waters. Investment in two comparable sized diesel-powered vessels is also analyzed for comparison. Annual operating cost and returns are projected over a 15-year time horizon. Sensitivity analysis of investment performance is conducted using alternative assumptions about fuel prices and key vessel financing parameters. Analysis of financial projections indicates that investment performance of sail-assisted fishing boats is inferior to conventional diesel-powered boats given current fuel prices, costs of borrowed capital, and vessel acquisition costs. This conclusion would not be altered if fuel prices were to double from their current levels. However, the relative financial performance of diesel and sail-assisted vessels does appear to be sensitive to perturbations in key financial parameters, particularly the purchase price of motorsailers.

The objective of this article is to provide a different and comparative line of analysis which is useful in further assessing the desirability of procuring and operating sail-assisted commercial fishing vessels in Hawaiian waters. Due to the limited range of vessel types and fishing operations under consideration, the analysis presented here is not intended to indicate actual investment prospects of sail-assisted vessels in all other fishing contexts. Nevertheless, a more complete understanding of the general potentials and limitations of sail-assisted technology will hopefully be achieved.

The discussion begins with a historical overview of the transition from sail to motor power by the U.S. commercial fishing fleet. Economic forces contributing to renewed interest in sailing technology are identified and alternate approaches to harnessing wind energy for commercial fishing are also briefly reviewed.

In the second section, attention is devoted to determining whether investment performance of motorsailing fishing boats is superior to that of conventional fishing boats. Within the framework of a case study of commercial fishing in Hawaiian waters, an appraisal is made of the projected contribution of sail-assisted vessels toward achieving reductions in total annual operating costs. Fifteen-year cost-earning projections are made for four sail-assisted and diesel-powered vessels, and sensitivity analyses of financial projections are discussed. Finally, conclusions are drawn regarding further adoption of sail-assisted vessel technology by the U.S. commercial fishing fleet.

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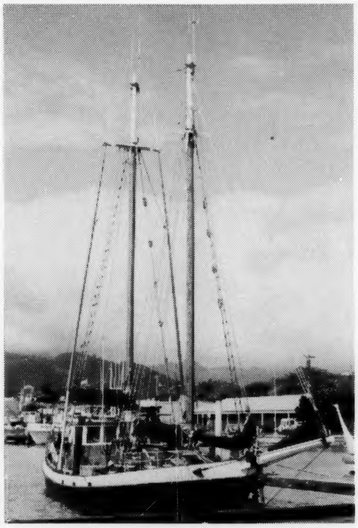

The *Cornucopia*, a sail-assisted vessel docked in Honolulu. Photo by Rick Klemm, University of Hawaii Sea Grant Extension Service.

A Historical Perspective

As recently as 1920, most of the U.S. commercial fishing fleet was propelled by wind. Within three decades, however, economic changes created strong incentives for fishermen to abandon their sailing heritage. Particularly important

was the increased availability of inexpensive fuels and reliable mass-produced marine engines. Altered market conditions, specifically a shift in consumer preferences toward fresh fish and away from salted and otherwise preserved fish products, also contributed to making speedier motor-powered vessels attractive investment alternatives.

Industry-wide conversion to motor power came in several stages. An initial development of commercial motor/sail fishing occurred in England during the late 1870's with the introduction of steam-powered trawling (March, 1953). Somewhat earlier, sailing trawlers were towed to North Sea fishing grounds by steam-powered tugboats. Tugs would continue to tow the trawlers around the grounds during periods of calm. A natural outgrowth of this practice was to install coal-fired steam engines directly on the sailboats and dispense with the tugs. According to March (1953), this adaptation took place over a time span of 30 years.

In the United States, transition to motor power was pioneered by fishermen who retrofitted sailing vessels with low horsepower engines (Gardner, 1982; Traung, 1955). Experiments at finding an efficient combination of sail and motor power eventually gave way to a new generation of vessels designed to operate solely on diesel or gasoline engines. The competitive edge afforded by the new technology was substantial. Although motor-powered vessels required regular and costly engine maintenance, the need for labor-intensive handling and upkeep of sails and rigging was eliminated. A typical crew of three or four could thereby be reduced to one or two. Motor power afforded greater overall dependability, faster transit speeds, and roomier hold capacities and living accommodations. A wider repertoire of fishing gear could also be used.

Since 1950, commercial fishermen's reliance on motor power has become deeply rooted. A natural outgrowth was increased dependency on fuel as a primary production input. In part, this phenomenon was the result of widespread adoption of efficient but relatively fuel intensive fishing methods such as mid-water and deep-water trawling, purse seining, long lining, and open-water trolling (June, 1950; Broadhead, 1962). Furthermore, as fishing gear and vessels became more costly, transit speeds and fuel consumption increased to minimize unproductive travel time. Other contributing factors included use of fuel-inefficient hull and propeller designs, and high energy demands to service cold storage and living facilities (Norship, Inc., 1981).

Table 1.—Price indexes for gasoline, diesel fuel, and edible fish products, 1967-81.

Year	Wholesale diesel price index[1] (1967=100)	Regular retail gasoline price index[1] (1967=100)	Ex-vessel edible fish price index[2] (1967=100)
1967	100.0	100.0	100.0
1968	101.9	101.0	108.8
1969	102.4	105.7	124.5
1970	106.5	108.8	128.9
1971	110.0	111.5	141.9
1972	111.3	107.9	168.9
1973	139.7	119.0	223.8
1974	272.0	178.7	237.8
1975	309.4	201.3	240.7
1976	337.0	209.7	303.9
1977	383.8	224.3	343.7
1978	408.5	245.1	398.7
1979	573.9	388.1	454.9
1980	850.6	538.4	406.1
1981	1,058.1	618.5	439.9

[1]Source: USDC, 1970-82.
[2]Source: USDC, 1973-82. Data for 1981 is preliminary.

In the early 1970's, prevailing economic conditions warranted continued reliance on fuel. As shown in Table 1, ex-vessel fish prices were rising faster than fuel costs. This situation dramatically reversed itself following the oil embargo of 1973. Within 7 years, the wholesale diesel fuel price index increased by 1,000 points and the retail gasoline price index rose by 600 points. During the same time, the ex-vessel edible fish price index increased by just under 300 points.

Concern about the recent price trend for fuel relative to fish and other production inputs is one of the principal reasons underlying the renewed interest in sailing fishing vessels. Reintroduction of sailing technology has taken three distinct paths: 1) Retrofitting existing fishing vessels with sailing apparatus; 2) converting vessels with yacht hull designs into fishing boats, and 3) constructing new fishing vessels designed from the outset to be sail-assisted. While each of these approaches has its peculiar advantages and limitations, a common goal is to arrive at a cost-saving mixture of sail and motor power.

Retrofitting an existing fishing vessel with sailing apparatus is a relatively inexpensive way to take advantage of wind energy. The concept has been considered for the Florida snapper/grouper fishery (Kibert[1]; Shortall, 1981). Substantial fuel cost savings are reported to be achievable, especially on long-range trips where sails are utilized 40-50 percent of the time. To date, however, most retrofitting has been attempted on smaller fishing vessels working in nearshore waters. While this may appear to be a limitation of the technology, it is a distinct possibility that larger vessels up to 20,000 deadweight tons could also benefit from installation of sails as well (Close, 1978).

A second approach is the so-called "yacht conversion" method. Here the strategy is to build a fishing vessel using an easily-driven yacht hull. Boats of this type are currently being built in several U.S. shipyards and are generally constructed in 35- to 80-foot lengths. The primary economic advantage of the yacht conversion method stems from an efficient hull design which allows for fuel savings even while operating under full motor power.

The disadvantages of converting a yacht into a fishing boat are four. First, initial acquisition costs can be high. Secondly, the hold capacity afforded by a sailing yacht hull is generally limited to less than 30 tons. Third, workspace on deck may be also restricted, a feature that can result in reduced selection of fishable gear as well as gear handling bottlenecks. Lastly, it can be difficult to find an experienced crew who can safely operate a sophisticated sailing vessel of this size and at the same time catch enough fish to make the operation profitable.

A third approach is to design and build a sail-assisted fishing vessel from the keel up. The few boats of this type fishing in U.S. waters today are generally at least 60 feet in length with hold

[1]Kibert, C. J. 1981. The economics of sailpower for snapper-grouper boats of the Florida west coast fleet. Florida Sea Grant College Marine Advisory Program, Univ. South Florida, Tampa. Unpubl. manuscr., 23 p.

capacities exceeding 20 tons. Most are capable of fishing a wide assortment of gear within operating ranges of 2,000 miles. As with a converted yacht, an efficient hull design is used to trim fuel use while underway in either the motor or sail-assist propulsion mode. Primary disadvantages of a motorsailing fishing boat include high acquisition costs, deckspace shortage, and need for an experienced sailing crew.

Table 2.—Comparative specifications for sail-assisted and diesel vessels.

Vessel characteristics	Sail-assisted (47-foot)	Diesel (45-foot)	Sail-assisted (65-foot)	Diesel (65-foot)
Hold capacity (tons)	10	15	30	40
Freezer/cold storage	Ice	Ice	Spraybrine/ blast	Spraybrine/ blast
Engines (brake horsepower)	Main: 100	Main: 165	Main: 160 Aux: 100	Main: 340 Aux: 100
Fuel capacity (gallons)	700	1,500	4,000	7,000
Sail area (square feet)	850		1,600	
Purchase price[1] (1982 dollars)	$190,000 (new)	$150,000 (new) $80,000 (used)	$550,000 (new)	$480,000 (new) $250,000 (used)
Crew size (including captain)	3	3	4	4

[1]All vessels equipped with necessary fishing gear and standard communication/navigation electronics.

Investment Analyses

Analysis here focuses on the economics of procuring and operating sailing-motor vessels to fish Hawaiian waters. The principal objective is to compare and contrast the lifetime financial performance of sail-assisted vessels vis-a-vis fishing boats that use conventional diesel engine propulsion.

Two representative sailing vessels will be evaluated. The first is a 47-foot converted yacht used to fish tuna (handline and troll) and bottomfish within an operating radius of 100 miles from home port. The second is a long-range craft capable of fishing for albacore and bottomfish in the Northwestern Hawaiian Islands, 1,500 miles from Honolulu. For comparison, investment in two comparably sized diesel-powered vessels is also analyzed.

Data on vessel design characteristics, fuel usage rates, catch rates, expenses, and fishing practices were obtained from four sources: 1) Personal interviews with owners and skippers of three Hawaii-based sail-assisted fishing vessels, 2) personal interviews with owners and skippers of comparable sized diesel-driven fishing boats, 3) telephone interviews with representatives of companies building sail-assisted and diesel fishing boats, and 4) vessel and engine manufacturer's published technical specifications. Characteristics of the four vessels under investigation are given in Table 2.

Apart from propulsion differences, sail-assisted and motor-driven vessels within each size category share many similarities. For example, both exhibit the same fish harvesting capabilities as measured in terms of catch per operating day, and total annual catch. Unfortunately, lack of published data on the fishing performance of motor-sailers makes it difficult to verify whether the catch data obtained for Hawaii sail-assisted vessels are typical of sail-assisted vessels in general. One might suspect that factors such as deck space limitations, reduced transit speeds, and gear handling deficiencies might reduce the relative fish catching power of a fishing motorsailer. Evidently, however, these factors do not impinge on the vessels under study here.

A second similarity is that all vessels are equipped with main engines. Although the motorsailers rely on relatively less powerful engines, they utilize main engines to operate hydraulic fishing equipment, increase speed and maneuverability when fishing and docking, and provide supplementary power when traveling against prevailing winds or in periods of slack winds. In addition to main engines, both larger boats are also equipped with auxiliary engines for electric power generation and to drive on-board freezing units.

Despite likenesses in vessel physical configurations, procurement costs of the sail-assisted vessels are considerably higher than those reported for comparable motor-powered fishing boats. Two explanations for this phenomenon can be offered. One reason stems from the fact that sail-powered fishing vessels are a novelty in the U.S. diesel-dominated fishing boat market. High unit prices are probably attributable to short supply and the failure of builders to realize economies of scale in production. Another contributing factor is that the sail-assist concept entails installation of two propulsion systems and a consequent increase in production costs.

Annual fuel requirements for all vessels under study are given in Table 3. In arriving at these projections, no special restrictions have been imposed on vessel operations to minimize annual fuel demands. This is because the fuel consumption rates given here are largely based on actual reported 1980-81 fuel usage. It is assumed that the consumption amounts are consistent with achievement of overall vessel financial performance objectives. Reported amounts may, however, reflect some operational suboptimization, particularly with regard to transit speeds (Alderton, 1981; Digerness, 1980). Furthermore, actual fuel consumption will vary depending on where fishing occurs, the types of fishing activities conducted, and general weather conditions.

Based on projected fuel usage rates, it is anticipated that a 47-foot vessel equipped with sailing apparatus will realize a 37 percent savings on annual fuel use compared with its 45-foot diesel-powered counterpart. Overall annual fuel savings for the larger 65-foot sail-assist fishing vessel drop slightly to 36 percent despite the fact that it realizes a relatively higher fuel savings (53 per-

Table 3.—Projected annual fuel consumption by vessel type.

Vessel type	Transit time				Fishing time				Other[1]	Total
	(gal./hour)	(hours/trip)	(trips/year)	(gal./year)	(gal./hour)	(hours/day)	(days/year)	(gal./year)	(gal./year)	(gal./year)
Sail-assisted (47′)	2.0	18	25	900	1.0	18	225	4,050	100	5,050
Diesel (45′)	4.0	18	25	1,800	1.5	18	225	6,075	100	7,975
Sail-assisted (65′)	[2]4.0	340	6	8,160	4.5	18	160	12,960	500	21,620
Diesel (65′)	8.5	340	6	17,340	5.5	18	160	15,840	500	33,680

[1]Includes fuel use for engine warmup, dead drift, and port turnaround.
[2]Represents an average of fuel use rates on trips to the Northwestern Hawaiian Islands (3.0 gallons per hour) and return trips to Honolulu (5.0 gallons per hour). The difference is due to prevailing winds.

Table 4.—Baseline financial assumptions.

Item	Amount	Frequency of occurrence
1. Expected vessel useful life	15 years	
2. Salvage value	20% of vessel purchase price	Year 15
3. Maintenance on vessel and gear	10% of vessel purchase price	Annual
4. Engine rebuild	$6.00/b.h.p.	Years 5, 10
5. Sail replacement	$8.00/sq. ft.	Year 7
6. Insurance (hull and P&I)	4% of vessel purchase price	Annual
7. Moorage fees	$21.00/ft.	Annual
8. Diesel fuel	$1.10/gallon	
9. Ice	$22.00/ton	
10. Lay system	50% of net operating revenues to captain and crew, 50% to vessel	
11. Food and stores	$8.00/person	Daily
12. Equity share of financing	25%	
13. Loan duration	15 years	
14. Loan interest rate	13% of outstanding loan balance	Annual
15. Depreciation	Straight line	Annual
16. General inflation rate	7%	Annual
17. Fuel inflation rate	7%	Annual
18. Discount rate	13%	Annual

cent vs. 50 percent) during its transit operational mode. Annual fuel cost reductions of 35-37 percent are slightly higher than the 30-35 percent reductions projected elsewhere by Shortall (1981), and considerably lower than the 75 percent fuel savings calculated by Sorensen-Viale (1981).

Annual operating revenues, net of selling costs, are assumed to be identical for comparable-sized vessels. If, as mentioned earlier, sail-assisted vessels generally have relatively less fish catching power, then this assumption clearly biases the financial projections in favor of the motorsailer alternatives. The 45- and 47-foot boats are projected to generate $125,000 in revenues each year while the larger vessels each bring in $390,000 worth of fish annually. These annual revenues imply an average daily catch worth $555 and $2,440 dockside for the smaller- and larger-sized boats, respectively. It should be noted that daily catch rates of these amounts will, on average, result in less than full capacity hold utilization for all vessels under consideration.

Baseline financial parametric assumptions are detailed in Table 4. The assumptions apply to all vessel types with the exception of sail replacement costs which are borne only by motorsailers. In the baseline model, it is assumed that a 13 percent interest charge is assessed on the outstanding share of the vessel purchase price which is financed with borrowed capital (75 percent). However, since a 7 percent general inflation rate is presumed, the real inflation-adjusted loan interest rate is 6 percent. It is also anticipated that fuel prices will increase at the general inflation rate during the relevant 15-year investment period.

Insurance charges in the baseline model are calculated as a straight percentage of vessel purchase price. This linear relationship between insurance premiums and vessel value tends to work against sail-assisted vessels which are more costly to replace. Yet, it is consistent with the workings of Hawaii's marine insurance market (Samples, 1982). Admittedly some owners of motorsailers may incur reduced premium rates due to the lower risks of having to pay towing fees in the event of major engine breakdowns. This, however, does not appear to be the case for Hawaii-based sail-assisted fishing boats.

Proforma cost-earning statements were prepared for each year within the 15-year investment planning period. Calculated net present values (NPV) of before-tax net income streams were positive for all vessel types when calculated using a 6 percent real discount rate. NPV was consistently higher for the diesel vessels under study. Furthermore, diesel vessels yielded a higher average rate of return on owner's equity investment compared with the motorsailers. The 47-foot motorsailer returned 27 percent of owner's investment on average annually compared with a 54 percent annual return for its 45-foot diesel counterpart. Similar comparative average rates of return on owner's equity were evident with the larger 65-foot fishing vessels.

Annual cost-earnings (1982 dollars) averaged over the 15-year investment period are given in Table 5 for all vessels under investigation. These data help explain the relatively inferior financial performance of the motorsailers. In large part, the matter reduces to the fact that high purchase prices, and accompanying high maintenance and insurance costs, overwhelm operating cost savings afforded by sailing technology. Consequently, although a 47-foot sail-assisted fishing boat can save nearly 40 percent each year in fuel expense, this savings contributes little to overall total operating cost reductions relative to the additional overhead that the motorsailer creates. This is true because fuel expenses represent only 5 percent of total fishing costs for the 47-foot boat. Interest charges, maintenance, and insurance payments, on the other hand, together compose nearly 28 percent of total costs.

The fact that fuel expenses are a small portion of costs results in a situation where the relative financial performances of the four vessels are not significantly altered if a fuel price of $2.00 per gallon is used in the cost-earnings

Table 5.—Baseline proforma average annual cost-earnings (1982 dollars) for sail-assisted and diesel fishing vessel operations in Hawaii.

Item	Vessel type			
	Sail-assisted (47-foot)	Diesel (45-foot)	Sail-assisted (65-foot)	Diesel (65-foot)
Gross revenues	$125,000	$125,000	$390,000	$390,000
Fixed costs				
Maintenance	19,000	15,000	55,000	48,000
Insurance	7,600	6,000	22,000	19,200
Depreciation	10,133	8,000	29,333	25,600
Interest	4,443	3,703	18,284	11,849
Moorage	987	945	1,365	1,365
Other repairs[1]	533	132	1,061	352
Variable costs				
Fuel	5,555	8,773	23,782	37,048
Food	5,760	5,760	8,640	8,640
Ice and bait	2,550	2,550	—	—
Crew shares	55,568	53,959	178,789	172,156
Return to labor, management, and equity	12,871	20,178	51,746	65,790
Net present value	58,913	147,572	363,631	515,764
Average return on investment	27%	54%	38%	55%

[1]Amortized costs of engine rebuild and sail replacement.

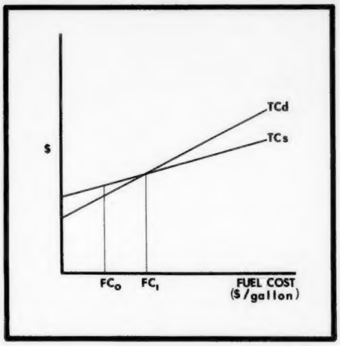

Figure 1.—Breakeven fuel costs for sail-assisted and conventional commercial fishing vessels.

projections. A price increase from $1.10 to $2.00 per gallon (an 81 percent increase) will add only an additional $7,177, or 7 percent, to the annual total costs of operating a 45-foot diesel boat. It would take a larger fuel price increase before the diesel vessel would be more costly to operate compared with the sail-assisted boat. This phenomenon is illustrated in Figure 1. Here, the total annual costs of operating a sail-assisted vessel (TCs) and a diesel vessel (TCd) are compared at various fuel cost (FC) levels. Starting with current fuel costs FC_0, it is clear that TCs exceeds TCd. This is attributed to the higher fixed costs of the motorsailer. The relative cost differential persists until fuel prices reach FC_1. Above this price, sail-assisted vessels are more cost-effective. In the case of the 45-foot diesel and 47-foot sail-assisted boats, FC_1 is calculated to be $6.10 per gallon. At this fuel price, the average annual total costs of operating both vessels are equalized, all other costs remaining constant. For the larger vessels under study, breakeven fuel price equals $3.43 per gallon. It is important to be cognizant of the fact, however, that at these higher breakeven fuel prices, total costs of vessel operations are high enough to make investment in either the sail-assisted or diesel vessels unattractive.

In view of the sizable contribution which debt service charges make to total annual costs of operating a sail-assisted fishing boat, sensitivity analyses were conducted by varying the following financial parameters: 1) Interest rates; 2) owner's equity share of vessel financing; 3) original purchase price; 4) discount rate; 5) insurance rate, and 6) maintenance costs.

Variations of 50 percent in individual parameters from baseline values have no discernable impact on the relative lifetime financial performance of the four vessels under study as long as the parametric changes are assumed to apply across the board to all boats. However, favorable changes in selected parameters affecting only a single boat can result in noticeable shifts in relative financial outcomes. This is particularly true for assumptions regarding sail-assisted vessel acquisition cost due to the linearities which exist in the finance model between vessel purchase price and insurance, maintenance, and depreciation expenses. For example, a 10 percent reduction in the acquisition costs of the sail-assisted vessels (holding all other parameters at baseline values) improves their relative financial performance just enough so that the present value of operating costs of the motorsailers is slightly less than their diesel powered counterparts.

Conclusions

The purpose of this article is to provide a further indication of the near-term desirability of owning and operating sail-assisted fishing vessels. Results from the case study of fishing in Hawaiian waters strongly suggest that at current fuel costs, interest rates, and acquisition costs, investment in sail-assisted vessels vis-a-vis conventionally powered boats is not economically prudent. In comparing the relative financial performance of the two vessel types, it appears that the fuel cost savings afforded by sailing technology are not great enough to offset greater fixed costs associated with financing, insuring, and maintaining the more expensive motorsailers. This conclusion would not be significantly altered if the price of fuel was to increase threefold from its current level. Furthermore, the competitive edge presently afforded by the diesel powered boats is even more pronounced if the fish catching of sail-assisted vessels turns out to be generally inferior.

Under what circumstances would sail-assisted vessels be an attractive means of reducing reliance on motor fuels? A sizable reduction in the real price of acquiring the technology would be an important prerequisite. Conceivably this might be accomplished several ways. One alternative not analyzed in this article is to focus efforts on retrofitting existing vessels with sailing gear. Admittedly this avenue is not available to all boat owners but it may yet prove to be the most economical path to reintroduce sail-power to U.S. fishermen. Further engineering and economic studies are needed to explore this possibility.

A second option available to some fishermen (but not to the industry as a whole) is to wait until the relative prices of motorsailers drop as vessel construction activity unfolds and as more used sail-assisted vessels appear on the market. If, in addition, these vessels could be financed at a reduced future interest rate, vessel operating costs would become more reasonable.

Finally, it is important to mention that this case study has focused on a narrow range of vessel types and fishing activities. In particular, the boats under study typically have an operating cost structure where fuel is a relatively small cost component. Cost savings generated by installation of sails are consequently correspondingly small. This situation may not hold true in other U.S. fisheries, such as Texas' Gulf shrimp fishery, where fuel costs are a relatively large cost item. In instances where fuel represents 30-50 percent of total operating costs, it may be the case that sail-assisted fishing boats are a cost-effective investment alternative. Investigation of the expected financial performance of motorsailers for such fisheries should be encouraged.

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Experimental Squid Jigging Off the Washington Coast

ROGER W. MERCER and MICHELE BUCY

Introduction

In the spring of 1981, the Northwest and Alaska Fisheries Center (NWAFC) of the National Marine Fisheries Service was contacted by Captain Jerry Sweeney of the salmon charter vessel *Tres Cher* in regard to squid jigging as an alternative to the declining salmon charter fishery off the Washington coast. A review of existing literature on squid yielded several pieces of information which indicated some potential for a nail squid, *Onychoteuthis borealijaponicus*, or flying squid, *Ommastrephes bartramii*, fishery off the Washington coast. Marine mammal stomach content information (Kajimura et al., 1980; Fiscus, 1982) indicated that nail squid might be found along the Washington continental shelf at the head of submarine canyons. Experimental squid fishing conducted off the coast of British Columbia during 1980 (Bernard, 1981) resulted in catches of flying squid and nail squid, and reports from Japan (Okutani, 1977) indicated that both species were taken commercially by Japanese vessels for domestic markets.

In light of this information, a decision was made to conduct experimental squid fishing off Washington during the summer months of 1981. Two Japanese Sanpar[1] squid jigging machines belonging to the NWAFC were loaned to Captain Sweeney for comparison with his own Swedish Kemers Atlanter machines during the planned experimental squid jigging trips. These machines were mounted on the *Tres Cher* at its berth in Tacoma, Wash. The vessel was then moved to Westport, Wash., in early May to begin squid fishing experiments.

This paper documents this experimental squid fishing and, especially, describes in detail what was learned regarding jigging of oceanic squids.

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[1]Mention of trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—In the spring of 1981, the Resource Assessment and Conservation Engineering Division of the NMFS Northwest and Alaska Fisheries Center loaned two squid jigging machines to Captain Jerry Sweeney of the fishing vessel Tres Cher. *These were used along with four of his own machines for experimental squid fishing off the Washington coast. This experimental fishing was prompted by reports of possible commercial quantities of nail squid,* Onychoteuthis borealijaponicus, *and flying squid,* Ommastrephes bartramii, *in the northeastern north Pacific Ocean. Fishing locations were selected based on northern fur seal,* Callorhinus ursinus, *stomach content data which indicated either or both species of squid might be found over depths greater than 200 m at the head of submarine canyons. Nocturnal squid jigging operations were conducted as an adjunct to daylight jigging for black rockfish,* Sebastes melanops, *or trolling for albacore,* Thunnus alalunga. *The* Tres Cher *was outfitted with tuna trolling gear, fish jigging machines, and squid jigging machines.*

A total of 1,261 squids were caught during 21 nights of jigging from 10 May to 14 September 1981. Two of the squid caught were flying squid and the rest were nail squid. About half of the squid caught were measured and examined for gender and sexual maturity. Squid were not captured in commercial quantities during these experiments, but it is felt that commercial quantities of nail squids might be available off the Washington coast during periods when coastal upwelling occurs.

Methods and Materials

The *Tres Cher* is a 17.1 m (56-foot), twin screw salmon charter vessel powered by two Volvo-Penta TMD-120 300-horsepower diesel engines. An Isuzu diesel electrical generator provides 20 kW of 60 Hz electrical power at either 230 or 115 volts. Initially, two recording depth sounders were used to search for squid schools. These were a Morrow JMF-151G system used with a 50 kHz transducer and a Si-tex HE-32E system with a 200 kHz transducer. A JRC/JFV-516 color recorder was installed in mid-August and slaved to the Morrow 50 kHz system. Navigational equipment included a Raytheon Pathfinder 2800 radar, and a Morrow Loran C system which included an LCA-3450 receiver, a CS-3450 steering computer, and an XYP 4000 plotter.

Lighting equipment consisted of three 1,000-watt incandescent lamps placed near the jigging machines on the port quarter of the vessel. In addition to the incandescent lamps, two pairs of 3,000- and 1,500-watt quartz halogen floodlights were positioned on the mast facing forward and aft, respectively.

Surface water temperature was measured with a bucket cast thermometer. Subsurface temperatures were measured to a depth of 30.5 m using a Heathkit

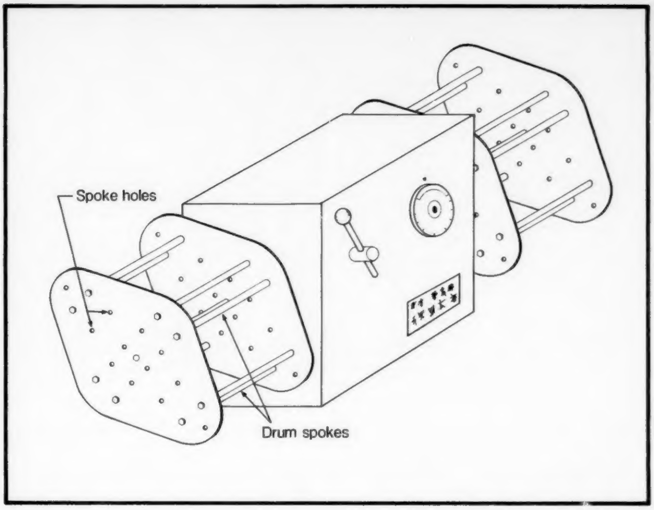


Figure 1.—The automatic jigging machine used aboard the fishing vessel *Tres Cher* in 1981 off Washington. Moveable drum spokes allow adjustment of drum eccentricity and effective diameter.

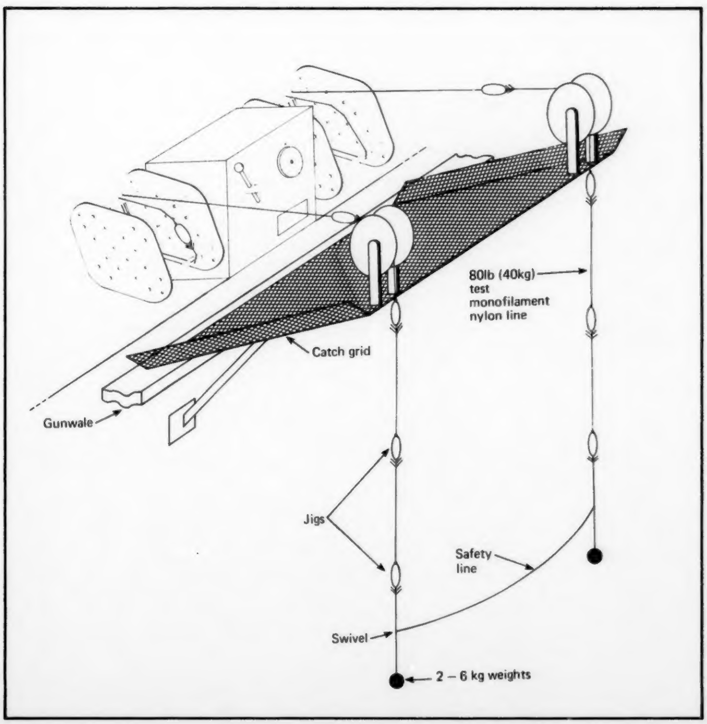


Figure 2.—Gear arrangement found most successful during experimental squid jigging aboard the *Tres Cher* in 1981 off Washington.

Thermospot thermometer. Thermospot temperatures were indicated in Fahrenheit and converted to Celsius. Corrections were applied to the Thermospot values per calibration checks against the bucket cast thermometer. National Weather Service sea surface thermal analyses were obtained on a weekly basis and used to help locate areas of coastal upwelling.

Fishing gear used for squid included sport rods (hand jigging), two Japanese Sanpar Models 76-2 and 7-2 squid jigging machines (Fig. 1, 2), and one Swedish Kemers Atlanter cod jigging machine rigged with an adapter drum for squid jigging. Usually only one jigging machine was operated at a time. Dip nets with 45.7 cm diameter and 4.6 m aluminum handles were also used to capture squids near the surface. A 50 fathom long by 4 fathom deep gill net of 50.5 mm (2¼-inch) stretched mesh was deployed off the bow during several early trips as a combination drogue and sampling tool.

The selection of fishing locations was based on a study (Fiscus, 1982) of stomach contents of northern fur seals, *Callorhinus ursinus*, which indicated that either or both species of squid might be found over depths greater than 200 m at the head of submarine canyons. Site selection each evening depended upon sea surface temperature, presence and concentration of seabirds such as petrels and shearwaters, presence of floating jellyfish, *Velella velella*, and density of any scattering layer detected by either of the sounders. Thermal boundaries were sought as indicators of boundary and strong thermoclinal conditions often associated with oceanic squid species (Okutani, 1977; Naito et al., 1977b). Generally, albacore, *Thunnus alalunga*,

fishing was conducted during daylight hours along the blue-water edge (thermal boundary) so the vessel was usually close to good "squid water" at sunset. If a scattering layer was detectable by the sounders, an area of peak target strength for the Si-tex 200 kHz sounder was generally chosen for a starting place.

After an initial jigging site was selected, the vessel would lay to and await sunset. If winds were above 10 knots, a drogue was deployed from the bow of the vessel to prevent excessive rolling motion. A 50-fathom (50.5 mm mesh) gill net was initially used for a drogue but was replaced later in the summer by a 6 m diameter parachute drogue. Rate and direction of drift were monitored using the Loran C and XY plotter. After sundown, quartz-halogen floodlights and incandescent lights were turned on to attract squid and jigging machines were started. Placement of the lamps in relation to jigging machines (Fig. 3) was in accordance with that found successful in other squid jig fisheries (Bernard, 1980; Ogura and Nasumi, 1976). Behavior of the scattering layer was monitored on echo sounders, and the presence of squid or bait fish at the surface was noted. Hand jigging was often conducted in conjunction with automatic jigging to help attract squid to the boat and to determine what type of jigging motion might be most effective. Rate of drop and retrieval and pause interval on the jigging machines were adjusted to coincide as closely as possible to that found successful by hand jigging. Quartz-halogen floodlights were turned off periodically to help concentrate squid under the incandescent lamps. If no squid were observed in the first hour or two, the gear was brought in and the vessel would search for a more productive site using the sounders to detect a heavier scattering layer. Shark lines were frequently deployed in an attempt to catch any sharks which might be attracted to the boat before they could foul the jigging gear. Squid jigging operations were secured at dawn.

Captured squid were measured, sexed, and examined for sexual maturity when they were to be sold dressed. When whole squid were to be delivered, only measurements of dorsal mantle length were obtained. Whole and cleaned squid were held on ice for up to 3 days in stackable, self-draining, plastic tubs (102 × 61 × 30 cm) before delivery.

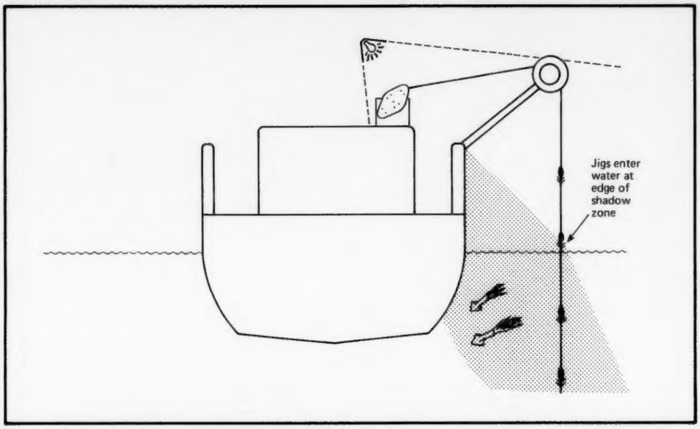


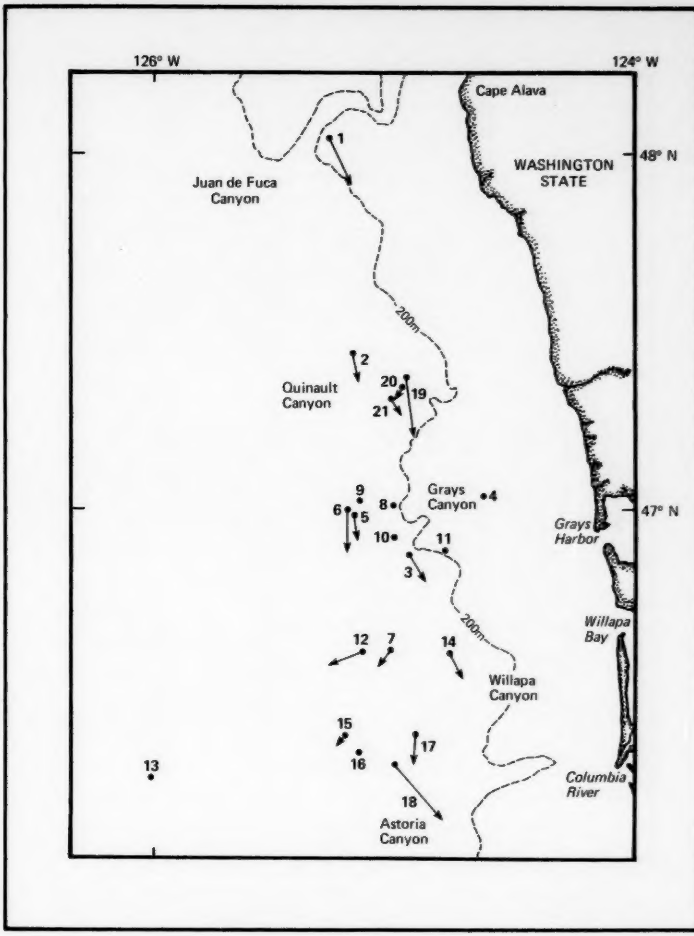
Figure 3.—Lighting arrangement found to be most effective for nail squid during the *Tres Cher* jigging experiments in 1981 off Washington.

Table 1.—Station and catch data including water temperature and lunar phase for experimental fishing stations of the fishing vessel *Tres Cher* in 1981 off Washington.

Station No.	Date	Location: Lat. N	Location: Long. W	Time	Temperature (°C): Surface	Temperature (°C): 100 ft	Catch (no.): Total	Catch (no.): Taken on jigs	Minimum fishing time (min.)	Lunar phase
1	5-10	48°02.4	125°16.6	2155	10.0	6.7				
	5-11	47°54.7	125°10.8	0400		6.7	0	0	365	1/4
2	5-11	47°26.0	125°09.7	2000	9.4	8.3				
	5-12	47°21.4	125°09.9	0430	8.9	8.3	6	1	510	1/4
3	6-13	46°52.7	124°56.3	2350	13.6					
	6-14	46°47.9	124°53.6	0540	14.5		8	4	350	1/4
4	6-25	47°02.5	124°37.5	0040	15.3		0	0	30	3/4
5	6-29	46°59.0	125°11.1	2100	15.3					
	6-30	46°55.1	125°09.8	0530	15.5		97	2	510	New
6	7-2	47°00.9	125°11.6	1800	14.8					
	7-3	46°52.8	125°10.9	0430	14.8		105[1]	2	630	New
7	7-11	46°36.0	125°00.9	2200	16.1					
	7-12	46°33.1	125°03.9	0500	15.9		111	6	420	1/4
8	7-16	47°00.0	125°00.0	2030	15.8		17	0	180	Full
9	7-17	47°00.5	125°08.7	0023	15.6		4	0	45	Full
10	7-17	46°54.5	124°59.9	0200	15.0		0	0	75	Full
11	7-17	46°53.3	124°47.9	0400	14.2		0	0	40	Full
12	7-28	46°35.2	125°07.5	2245	16.8					
	7-29	46°33.6	125°15.9	0300	12.5		2	0	255	New
13	7-29	46°13.8	126°01.5	2214	16.8		2	0	60	New
14	7-30	46°34.8	124°46.2	2300	16.5					
	7-31	46°31.7	124°43.1	0300	16.4		13	0	240	New
15	8-1	46°20.7	125°12.9	2200	15.8					
	8-2	46°19.8	125°13.5	0430	15.5	10.0	305	105	390	New
16	8-2	46°18.5	125°08.9	2145	15.8	9.4				
	8-2	46°18.5	125°08.9	2230	15.8		41	10	45	New
17	8-3	47°21.2	124°54.5	2130	15.6	7.2				
	8-4	47°16.9	124°55.3	0600	14.8		239	154	510	New
18	8-6	47°18.3	125°00.4	2345	15.0					
	8-7	47°07.6	124°48.9	0530	13.5		0	0	345	1/4
19	8-27	47°22.3	124°56.5	2045	15.7	6.6				
	8-28	47°12.1	124°55.5	0610	14.5		194	194	565	New
20	8-28	47°20.3	124°58.2	1900	15.4	7.7				
	8-29	47°18.4	124°59.5	0200	15.4		106	106	420	New
21	9-13	47°19.4	125°00.0	1925	14.3	8.2				
	9-14	47°15.5	124°57.7	0315	14.3		11	11	470	Full

[1] Two *Ommastrephes bartramii* included.

Figure 4.—Location and station number of sampling sites of the *Tres Cher* during 1981 squid jigging experiments off Washington.



Results

Experimental squid jigging was conducted during 21 nights between 10 May and 14 September 1981. Fishing locations (Fig. 4) were primarily at the head of submarine canyons in depths that exceeded 200 fathoms (366 m). A total of 1,261 squid were captured during the experimental fishing period (Table 1). With the exception of two flying squid taken on 2 July, the catch consisted entirely of nail squid. Catch rates were initially poor but improved as jigging expertise was acquired and water temperatures increased. Of the 1,259 nail squid captured, 595 were taken on automatic jigging machines and 664 were dip netted. No squid were captured in the gill net. Maximum catch rates of 30 pounds per machine per night were experienced later in the summer.

In addition to collecting information on the best conditions for jigging squid, biological data, such as dorsal mantle length (DML), gender, and sexual maturity, were obtained from some of the captured specimens.

A total of 687 nail squid and the 2 flying squid were examined. All were measured and 455 nail squid and 1 flying squid were sexed. The flying squid measured 404 mm DML and appeared to be an immature female. Data for the nail squid are presented in Table 2. None of the squid examined were sexually mature, but early signs of maturation (Murata and Ishii, 1977) were evident in male nail squids taken in early August and in one female nail squid taken on 13 September.

Table 2.—Dorsal mantle length (DML) of male and female nail squid, *Onychoteuthis borealijaponicus*, captured during experimental jigging off the Washington coast in 1981.

	Sexes combined				Males			Females		
Date	Station no.	No. examined	Mean DML (mm)	S.D.	No. examined	Mean DML (mm)	S.D.	No. examined	Mean DML (mm)	S.D.
5/10-5/11	1	0								
5/11-5/12	2	2	235	22.6						
		3	92	3.0						
6/13-6/14	3	8	180	33.0						
6/29-6/30	5	97								
7/12-7/13	6	102	139	39.0						
7/11-7/12	7	70	145	28.6	31	139	21.4	39	151	34.4
7/16-7/17[1]	8									
	9	17	134		8	132		9	137	
	10									
	11									
7/30-7/31	14	13	191		6	193		7	188	
8/1-8/12	15	78	131	26.1	46	132	26.2	32	130	26.0
8/3-8/4	17	84	164	23.4	53	162	23.0	31	166	24.2
8/27-8/28	19	193	176	21.6	128	174	20.7	65	182	23.3
9/13-9/14	21	21	176	45.3						

[1]Four different stations fished during one night. Catch from all stations combined.

Several methods of processing squid for market were tested. Some squid were gutted and iced, others were iced in the round (whole). In both cases, a ratio of one part squid to one part ice was used. In-the-round nail squid were held iced in tubs for up to 3 days with no detectable loss of quality.

Discussion

Although large numbers of nail squid were attracted to the lights of the vessel on several occasions, it was difficult to tempt them into attacking the jigs. Several factors including sea state, light intensity and placement, jig shade, jigging motion, sea temperature, and lunar phase were found to affect the catch rate significantly.

One of the most important conditions for catching squid was placement and intensity of artificial lights. High light output all around the boat attracted the most squid, but too much direct light on jig lines reduced the catch significantly. Three 1,000 watt incandescent lights were rigged with directable shades as suggested in Ogura and Nasumi (1976) and focused over the gunwale to strike the water at an approximate 45° angle (Fig. 3). This arrangement of the incandescent lights permitted the jig lines to enter the water at the edge of the shaded zone resulting in an improved catch rate. Further improvements in catch were obtained by turning off the quartz-halogen floodlight that illuminated the port quarter of the vessel where the jigging machines were located and by intermittently turning all quartz-halogen floodlights on and off. By this method, the squid could be attracted to the vessel and then concentrated under the incandescent lamps in the area of the jigging machines. The squid seemed to prefer remaining in the shadow area under the vessel until they sighted a jig or prey in the lighted area, at which time they rushed out to attack.

Because of the importance of light intensity to squid jigging, lunar phase has a pronounced effect upon the success of fishing operations (Arnold, 1979; Bernard, 1981). When the moon was full and the sky clear, very few squid were attracted by our lights and, conversely, the best catch rates were experienced on the darkest nights.

Sea temperature was measured carefully both at the surface and at a depth of approximately 30 m in an effort to locate temperature conditions similar to those where nail squid were found in the northwestern Pacific (Naito et al., 1977b). Squid were encountered and taken by jigs in greatest abundance in areas where the surface temperature exceeded 15°C. The best jigging success occurred on 28 August in an area where the surface temperature was 15.7°C and the temperature measured at 30 m depth was 6.6°C. Although this seems to indicate that nail squid may not be caught on jigs in surface waters below 15°C, these increased catch rates may relate more to improvement in jigging and lighting technique than water temperature. Nail squid are taken by jigs successfully in the western north Pacific in surface water temperatures of 11°-13°C (Murata et al., 1976).

Several colors and sizes of jigs and jigging motions were tested to determine the best combination. Catch rates did not seem dependent on the color of the jigs but, when few squid were around the boat, the lighter shaded jigs such as white, yellow, and clear were taken preferentially. When squid were plentiful around the boat and the catch rate was up, all colors and shades worked equally well. Size of the jigs also seemed to have little effect on the catch rate. Small squid were willing to attack jigs that were almost as large as themselves.

Jigging motion turned out to be very important in catching squid. The best motion varied in different locations and at different times. Hand jigging for squid was the quickest way to determine what the best motion and depth settings might be on any particular occasion. Retrieval rate of the automatic jigging machines could be adjusted by rheostat or reducing the drum diameter; jigging motion was achieved by moving the drum spokes to various positions to change the eccentricity of the drum (Fig. 1). A motion that worked well during August was achieved by adjusting the drums to maximum eccentricity and slowing the average retrieval rate to 51 m per minute with a 1-second pause for about every 4 m of line retrieved. This retrieval rate was considerably slower than the 70-75 m per minute found successful in other jig fisheries (Suzuki, 1963; Igarashi et al., 1968). It was found best to lower the jigs only as deep as necessary to attract the squid because tangles in the lines increased as more line was let out. It was not generally necessary to lower the bottom of the jig string deeper than 40 m. Although many squid followed the jigs up from the depths, almost all squid caught were observed to attack the jig just before it cleared the water during retrieval.

Sea state and wind conditions directly affected jigging success. Ideal conditions were calm seas and little wind. When wind velocity exceeded 10 knots a parachute drogue was deployed from the bow to minimize rolling motion and prevent an excessive drift rate. Rolling motion disturbed the motion of the jig lines causing occasional tangles and significantly reducing the catch rate. Although tangling could be minimized by changing to heavier weights (3-6 kg) on the jig lines, a sustained wind velocity exceeding 25 knots prevented successful jigging operations from the *Tres Cher.*

Another unexpected problem significantly affecting jigging success was interference from blue sharks, *Prionace glauca*, which were also attracted by the lights of the vessel. By striking at or becoming entangled in the jig strings, a shark could break off part or all of a 30-jig string which could prove costly in terms of time and gear lost. Shark lines were deployed fore and aft on the vessel in an attempt to intercept blue sharks before they could damage the jigging gear. Later communication with a Japanese squid jigging expert[2] revealed that sharks are a common problem in squid jigging and that no better method than rigging shark lines has been discovered.

In addition to learning how to locate and catch squids, some biological data were collected: DML, gender, and an

[2]Yutaka Ikeda, squid jigging consultant, Taito Seiko Co. Ltd., Imaasa Building, No. 1-21, 1-chome, Higashi-shimbashi, Minato-ku, Tokyo 105, Japan. Pers. commun., September 1981.

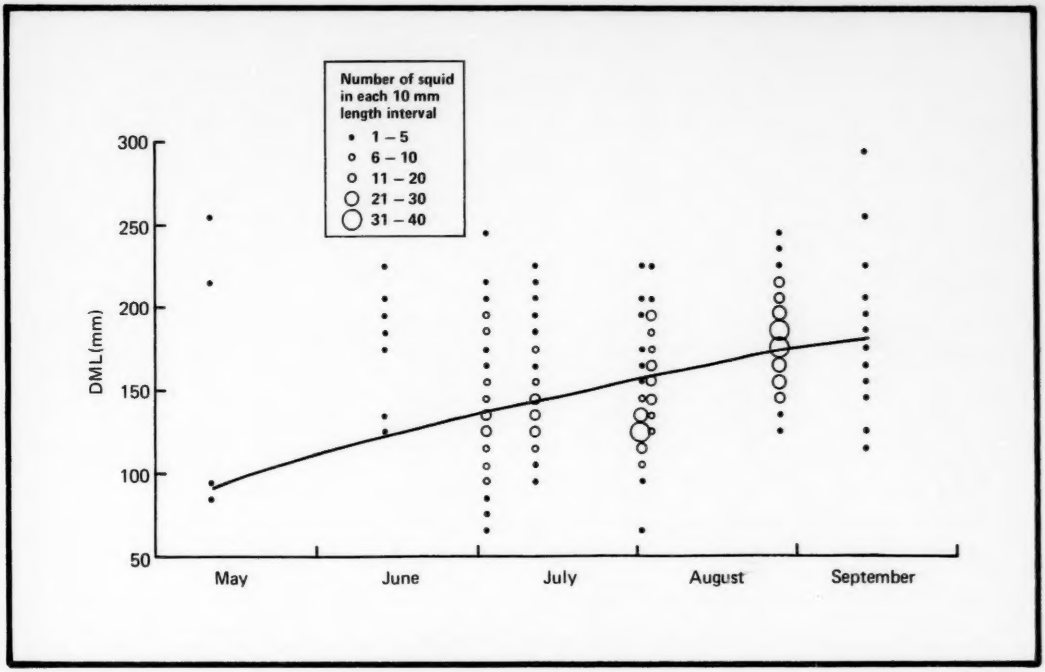


Figure 5.—Dorsal mantle length frequency of nail squid taken in 1981 off Washington during experimental jigging aboard the *Tres Cher.*

indication of sexual maturity. The two flying squid taken on 3 July had DML's of 410 mm and 220 mm. Mean dorsal mantle lengths for nail squid are presented in Figure 5 and in Table 2. There appeared to be an increase for one size group of nail squid in mean DML from 92 mm on 11 May to 176 mm on 28 August (Fig. 5). This reflects a growth rate of approximately 2 cm DML per month which compares well with that reported from the northwestern Pacific (Naito et al., 1977a; Murata and Ishii, 1977).

The wide range of observed nail squid DML (Fig. 5) made modal length analysis for age and growth information very difficult. Widely separated DML's are also reported in nail squid from the western north Pacific and, apparently, reflect different age groups and highly variable growth rates (Naito et al., 1977a; Murata and Ishii, 1977). Actual values of mean DML were 80-100 mm smaller than those reported from the western and central north Pacific during the same season (Naito et al., 1977a; Murata et al., 1976).

Although more length and maturity information, especially at different seasons of the year, is required to fully define age groups, growth, and spawning seasons, it was possible to draw some preliminary conclusions from our data. A hypothetical growth curve for the sampling period was drawn using modal DML for both sexes from stations where nail squid were measured. Squid from two jigging stations were excluded from the growth curve computation. The larger squid (235 mm average DML) that were caught on 11 May were representative of many more large squid which were observed around the boat but not captured; such numbers of large squid were not observed again until 13 September. Consequently, we feel that they probably represented a different age group which either spawned and died or departed the area before the 13 June trip. The eight nail squid that were measured from the 13 June trip were excluded because of the small sample size and poor curve fit. The shape of the growth curve suggests that nail squid caught during these experiments were probably hatched during mid- to late winter 1981.

Some of the squid taken during these experiments were examined for sexual maturity. Male nail squid (272) were examined for sperm packets while aboard the vessel and 9 additional nail squids (4 male, 5 female) were saved for laboratory examination by Clifford Fiscus (scientific consultant, Brier, WA 98036, August 1981). Sperm packets were observed developing in males during late July, and one female (294 mm DML) which was taken on 13 September

had nidamental glands which measured 103 mm in length and were orange in color. This coloration is reported to signify the onset of maturation (Murata et al., 1976). Divergence in size of males and females reported to occur during sexual maturation of nail squids (Naito et al., 1977a; Murata and Ishii, 1977) was not observed in these squid.

Although some signs of maturation were detectable in the nail squid taken during late August and early September, other signs such as size difference in males and females and the attainment of spawning size (300-370 mm DML), as reported by Naito et al. (1977a) and Murata and Ishii (1977) were not. For these reasons, we believe that the growth and maturation of our squid were probably 1-2 months behind the squid described by Murata and Ishii (1977); and, according to the hypothetical growth curve (Fig. 5), the nail squid taken off Washington probably would only reach a maximum size of 250-280 mm DML at spawning. Spawning for these squid would probably occur from early to mid-winter and subsequent hatching from mid- to late winter. Also, there may have been several age groups present off Washington during our investigations: One age group of nail squid represented by the large size group (235 mm mean DML) taken in early May, a second group represented by most of our catch from May to September, and a third group represented by many small (approximately 50 mm DML) squid observed on 13 September.

The effect of ocean currents and related migratory behavior of nail squid off the Washington coast should be studied. It is possible that nail squid migrate in a northerly direction past Washington to spawn in the north Pacific; this migration, if it occurs, would be similar to those reported for squid of the western north Pacific (Naito et al., 1977b).

Acknowledgments

The authors would like to thank Captain Jerry Sweeney for providing the fishing vessel *Tres Cher* without which these experiments would not have been possible. We also wish to thank Captain Sweeney, Captain Conrad Selfords, Mathew Sweeney, and Mike Bucy for their enthusiastic assistance in the pursuit of squid. Special thanks to Clifford Fiscus for his able assistance in identifying and determining sexual maturity of squid caught.

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Weight Frequencies for Striped Marlin, *Tetrapturus audax*, Caught Off Southern California

JAMES L. SQUIRE, Jr.

Introduction

Striped marlin, *Tetrapturus audax*, are caught by marine game fish anglers off southern California only during a brief period of the year, with most of the catch landed between 15 August and 15 October of any one year. The annual catch may range from 50 to 2,300 marlin but averages about 800. Angler catch rates are low off southern California when compared with those of other striped marlin fishing areas in the northeast Pacific, such as the area about the tip of Baja California Sur, Mexico (Squire, 1974). This area lying about 750 miles to the southeast of southern California is intensively fished by U.S. anglers (Talbot and Wares, 1975).

Catches in both the southern California and Baja California areas were sampled during 1967-70 for weight frequencies and other biological parameters by the National Marine Fisheries Service (Eldridge and Wares, 1974). The mean weight of marlin was found to be greater by about 16.8 kg (37 pounds) for landings in southern California when compared with landings near the tip of Baja California Sur, Mexico (Talbot and Wares, 1975), an area that is near the center of striped marlin distribution in the northeast Pacific.

The southern California fishery is near the northeastern limit of striped marlin distribution in the Pacific Ocean and marlin are caught in increasing numbers by this fishery during periods of sea surface temperatures of 20°C (68°F) or greater (Squire, 1974).

Geographical areas within the southern California Bight yielding high catches of striped marlin may vary between years, from a fishing area to the west and southwest of San Diego to an area between the mainland near Dana Point to and about Santa Catalina Island, a range of about 90 miles. The time distribution of the catch differs slightly between the Santa Catalina Island area and the area off San Diego. Figure 1 illustrates the major fishing areas for striped marlin relative to the locations of the weigh stations from which the data used in this report were obtained.

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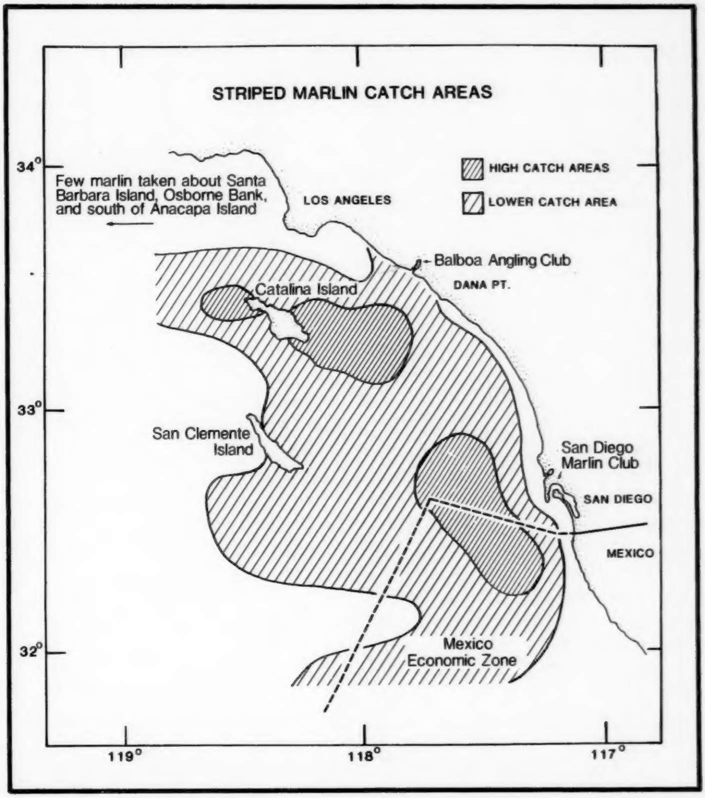

Figure 1.—Major catch areas for striped marlin off southern California.

In southern California the major locations for weighing angler-caught striped marlin are the San Diego Marlin Club, located on San Diego Bay, San Diego, Calif., and the Balboa Angling Club, located on Newport Bay, Balboa, Calif. Both clubs maintain weight records for all marlin landed, and the records compiled at these two locations represent an estimated 90 percent or more of the total southern California landings. Weights are assumed to be accurate as the marlin are weighed on scales that are certified by either the San Diego or Orange County Sealer of Weights and Measures. Marlin caught in the vicinity of Santa Catalina or San Clemente Islands are sometimes weighed at the town of Avalon, Santa Catalina Island, Calif. These marlin are frequently taken across the Catalina Channel to Newport Bay where they are reweighed by the angler at the Balboa Angling Club.

Weight frequencies from club weight records and the work of Eldridge and Wares (1974) are described. An analysis of trends in weight frequency, both by area and by year, is presented.

Data Sources

Striped marlin are usually weighed on the same day as they are caught, except for a few that are tagged and released or released on the fishing grounds. Special care, such as covering the marlin with a wet cloth or sheltering it from the elements to prevent dehydration after capture, is not usually taken. Since sea surface temperatures off the coast of southern California are in the range of 20-22°C (68-72°F) during the fishing season and offshore air temperatures are near that of sea surface temperature, the degree of dehydration before weighing is probably minimal. However, the magnitude of the weight difference between time of capture and weighing ashore is not known.

Weights are recorded in pounds of total or round weight. Marlin are not examined to determine sex so weights given in this paper represent a composite weight of both male and female marlin.

Data on the date landed and total weight are published annually in the yearbooks of both the San Diego Marlin Club and the Balboa Angling Club. Information is also included on the angler's name, boat captain, type of tackle, weight of fish, and time to land the marlin.

Weight records in this paper represent striped marlin weights for 15,138 fish. The Balboa Angling Club recorded weights for 6,620 marlin over a period of 36 years (1945-80); the San Diego Marlin Club has recorded weights for 8,518 marlin over a 21 year period (1960-80). Weight data for this review were obtained from the reports of Talbot and Wares (1975) and record books of the San Diego Marlin Club and the Balboa Angling Club. Typically, few marlin were reported weighed in July and November, and both clubs recorded the highest catch in September.

The only historical weight records of striped marlin for the early 1900's are those published by Jordan (1916) describing the average weight of 251 specimens landed at Santa Catalina Island from 1910 to 1916. For the 251 samples of "Japanese spearfish," *Tetrapturus mitsukuri*- (synonymy given by Jordan and Snyder, 1901), Jordan reported the average weight to be 82.6 kg (182 pounds). This weight would indicate mean size reduction of approximately 18.1 kg (40 pounds) when compared with the 1960-75 mean weight off southern California of 64.4 kg (142 pounds). The reduction in average weight by 18.1 kg (40 pounds) may be the result of fishing.

Weight Record Analysis

Data giving striped marlin mean weights by month and year, number of marlin in the sample and weight averages by month are presented in Table 1, for 21 years of San Diego Marlin Club data and 36 years of Balboa Angling Club data.

Figure 2 shows the percentage of landings by month for weight records compiled by the San Diego Marlin Club and the Balboa Angling Club; catch trend by month from both clubs' records were similar, with peak catches during the same month (September). Slightly higher landings (7 percent greater) were recorded for August (the beginning of the fishing season) from Balboa Angling Club records, when compared with San Diego Marlin Club records. The landing weights were slightly less (4 percent less) in the Santa Catalina Island and Channel area in November as reflected in the Balboa data compared with the San Diego area records. Effort data were not available; therefore, any catch percentage differences could be the result of variations in fishing effort.

Weights were grouped by 4.5 kg (10 pound) increments and plotted by year for data from 1945-80 for the months July through October, or by weight data for each season, to determine if any modal size groups could be observed moving through the fishery. An example of the weight structure of the catch is given in Figures 3a, b, and is typical of other years. The figures show that for 1963, a record catch year, little change is evident between weight groups during the months of July, August, September, and October. The landings weighed at the Balboa Angling Club appear to have a distribution similar to the catches landed at the San Diego Marlin Club.

Discussion and Summary

Biological research conducted at San Diego during the period 1967-70 indicated that of 462 marlin sampled, 67 percent were female. During the early part of the fishing season females were the predominant sex caught, with the sex ratio changing to about 50:50 later in the season. Females were heavier than males for a given length, and statistical tests indicate this difference to be significant (Wares and Sakagawa, 1974). Marlin landed at San Diego were heavier when compared with marlin of the same length near the tip of Baja California Sur, and at Mazatlán, Mexico, as determined by comparing weight as a function of eye (orbit) to tail fork length (Fig. 4).

There is a small difference in monthly mean weight of marlin landed at the Balboa Angling Club compared with weights recorded by the San Diego Marlin Club. The marlin weighed at the Balboa Angling Club averaged 4.1 kg (9.1 pounds) heavier in July when compared with those weighed at San Diego, 1 kg (4.5 pounds) heavier in August, 1.5 kg

Table 1.—Striped marlin mean weight by month and year as recorded from sport catches landed at the San Diego Marlin Club and Balboa Angling Club (the number of fish is in parentheses). Weight is in pounds (round weight) as recorded.

Year	July No. of Fish	July Mean wt.	August No. of Fish	August Mean wt.	September No. of Fish	September Mean wt.	October No. of Fish	October Mean wt.	November No. of Fish	November Mean wt.	Average weight
The Marlin Club											
1960	(3)	145.00	(96)	152.00	(276)	132.31					137.61
1961	(4)	170.00	(24)	168.33	(344)	140.47	(46)	141.73			142.50
1962	(1)	135.00	(16)	134.37	(39)	145.51	(1)	155.50			142.36
1963	(14)	136.42	(463)	136.92	(904)	132.07	(78)	116.66			132.83
1964			(95)	128.47	(422)	127.96	(371)	142.08	(79)	146.89	134.97
1965			(24)	122.29	(126)	139.44	(148)	146.48	(2)	145.00	141.58
1966	(6)	111.00	(112)	133.30	(367)	128.46	(97)	128.19	(2)	135.00	129.17
1967	(11)	124.09	(203)	122.24	(347)	121.13	(43)	131.74	(217)	145.41	128.42
1968	(12)	121.66	(43)	119.88	(331)	135.69	(146)	139.93	(59)	150.76	136.81
1969	(2)	110.00	(32)	143.75	(191)	146.30	(33)	148.93	(11)	153.18	146.33
1970	(2)	155.00	(31)	124.67	(32)	139.68	(30)	154.00	(1)	185.00	138.85
1971			(26)	137.50	(48)	147.50	(33)	146.0			144.60
1972	(2)	195.00	(17)	142.65	(75)	142.40	(29)	142.07	(2)	155.00	146.40
1973	(1)	195.00	(25)	145.40	(20)	145.50	(30)	151.30	(1)	205.00	149.14
1974	(4)	135.00	(57)	137.00	(90)	142.20	(133)	148.90	(10)	150.0	144.38
1975	(1)	175.00	(62)	150.00	(72)	152.40	(55)	152.40			151.70
1976	(1)	145.00	(10)	142.00	(63)	143.30	(60)	142.10	(5)	141.00	142.60
1977	(5)	135.00	(47)	145.76	(115)	152.48	(61)	157.30	(48)	158.75	153.21
1978	(3)	158.33	(40)	142.25	(148)	147.64	(239)	148.26	(75)	150.73	148.03
1979	(4)	135.00	(92)	144.13	(149)	141.11	(58)	152.50	(42)	156.43	145.62
1980	(3)	171.67	(185)	146.62	(198)	148.43	(123)	148.17	(14)	144.29	147.75
21-year mean	(79)	137.10	(1,700)	137.52	(4,357)	135.70	(1,814)	143.61	(568)	149.15	
Balboa Angling Club											
1945			(53)	138.58	(84)	137.97	(3)	121.66			137.85
1946			(82)	142.19	(91)	140.76	(13)	146.53			141.80
1947			(30)	149.66	(35)	139.00	(50)	144.40	(4)	150.00	144.32
1948			(27)	145.00	(60)	142.23					143.16
1949	(2)	190.00	(34)	139.41	(61)	146.47					144.89
1950	(3)	131.66	(40)	144.25	(120)	137.66	(45)	151.22			141.77
1951	(4)	167.50	(33)	143.78	(67)	163.33	(6)	163.33			144.72
1952			(80)	144.25	(281)	125.41	(56)	151.96			133.59
1953			(16)	161.25	(10)	147.00	(3)	178.33			158.10
1954			(19)	158.68	(26)	159.61			(4)	172.50	160.30
1955					(9)	163.88					163.88
1956			(23)	172.36	(31)	146.29	(50)	175.92			166.50
1957			(221)	159.54	(138)	149.02	(39)	160.89			156.03
1958	(55)	148.63	(46)	146.30	(47)	134.78	(115)	130.47	(6)	143.33	137.93
1959	(46)	146.95	(317)	129.79	(148)	129.59	(16)	146.25	(3)	138.33	131.77
1960			(75)	150.46	(71)	138.94					144.86
1961			(29)	153.62	(57)	137.45	(12)	138.33			142.34
1962			(8)	141.25	(12)	152.50					148.00
1963			(180)	134.86	(54)	133.14	(79)	139.05	(5)	133.00	135.58
1964			(35)	127.28	(143)	130.87	(238)	143.21	(59)	152.62	139.49
1965			(22)	137.72	(20)	147.00	(81)	145.50			143.69
1966	(4)	125.00	(62)	137.41	(91)	134.89	(68)	127.50			133.17
1967			(43)	135.46	(117)	127.99	(35)	132.28	(48)	147.70	133.97
1968	(5)	119.00	(68)	129.85	(103)	137.23	(82)	144.87	(36)	148.61	138.74
1969			(16)	153.75	(125)	142.36	(52)	146.92			144.52
1970			(26)	126.15	(51)	133.62	(15)	141.66			132.82
1971			(32)	152.19	(46)	132.39	(20)	154.50			143.37
1972			(22)	149.54	(12)	157.50	(16)	146.25			150.40
1973	(1)	155.00	(12)	135.00	(15)	144.33	(2)	155.00	(1)	205.00	143.71
1974	(13)	140.38	(85)	138.17	(116)	147.28	(112)	143.39	(3)	168.33	143.52
1975			(38)	146.05	(110)	149.45	(7)	155.00			148.87
1976	(2)	125.00	(61)	152.29	(59)	145.60	(54)	149.81	(17)	151.76	147.81
1977	(1)	125.00	(35)	144.71	(96)	155.94	(169)	150.74	(3)	148.33	151.58
1978	(1)	155.00	(37)	146.89	(50)	153.00	(46)	161.96	(2)	155.00	154.41
1979	(3)	158.33	(142)	138.73	(85)	139.06	(4)	152.50	(3)	178.33	139.83
1980	(2)	150.00	(63)	142.78	(32)	150.00	(8)	160.00	(3)	151.67	146.58
36-year mean	(142) 2%	146.20	(2,112) 32%	142.04	(2,673) 40%	139.02	(1,496) 23%	145.71	(197) 3%	150.81	
Combined mean, both clubs	(221)	142.94	(3,812)	140.02	(7,030)	136.96	(3,310)	144.56	(765)	149.58	

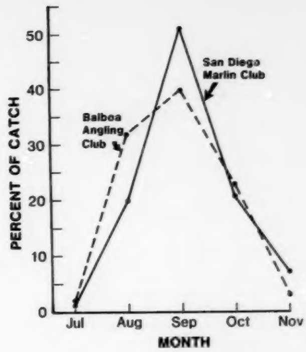

Figure 2.—Percentage of catch by month recorded for landings of striped marlin at San Diego (1960-80) and Balboa, Calif. (1945-80).

(3.3 pounds) heavier in September, and 0.7 kg (1.6 pounds) heavier in November.

Combined mean weights for the 15,138 marlin in the sample (Table 1) show a slight decrease in mean weight to 62.1 kg (136.9 pounds) during September, the month with the highest catch, when compared with weights for August and October. In October and November mean weight increased to 65.8 kg (145 pounds) and 68 kg (150 pounds), weights that are slightly above the weight observed at the beginning of the season.

Although the mean weight of marlin taken in recent years is only slightly higher than those weights recorded in the late 1940's, there occurred a period from 1953 through 1957 when anomalous weights were observed. In 1952 the average weight recorded at the Balboa Angling Club was 60.0 kg (134 pounds) with a catch of 417 fish, a catch which was well above the average landing of 184 marlin. In 1953 the catch was low (29 marlin) but the average weight increased 10.9 kg (24 pounds) to 71.7 kg (158 pounds) over the previous year (1952). The average weight continued to be well above the long-term average (64.4 kg or 142 pounds) during the next four seasons, 1954-57, with catches of 49, 9, 103, and 398 marlin respectively. In 1956 the average weight was the maximum recorded, 75.8 kg (167 pounds). Average weights decreased in 1958 to near the long-term average but with an above average catch of 269 mar-

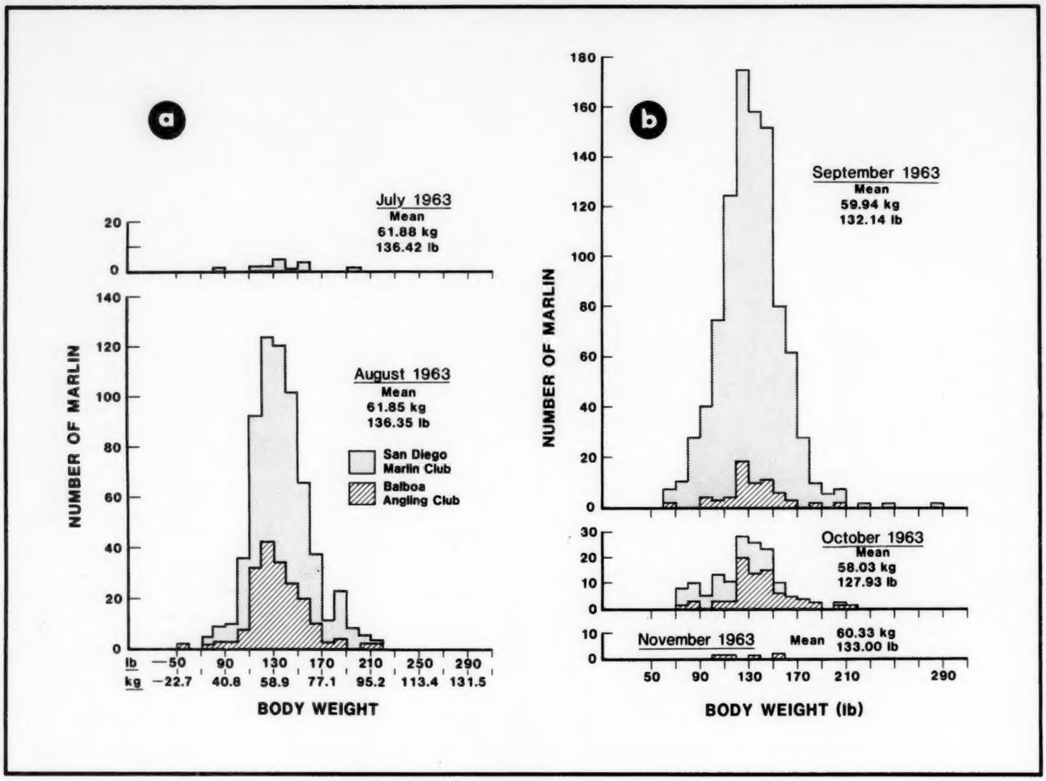

Figure 3.—Distribution of landing weights by 4.5 kg (10-pound) increments for the 1963 season.

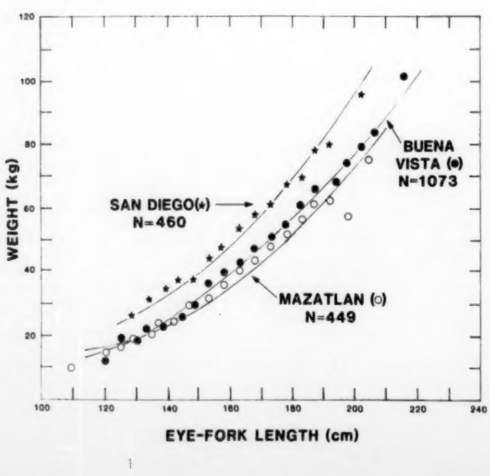

Figure 4.—Weight as a function of eye-fork length of striped marlin from the northeastern Pacific. (Buena Vista is located in the east side of the Baja California Mexico peninsula near the southern tip.) From Wares and Sakagawa (1974).

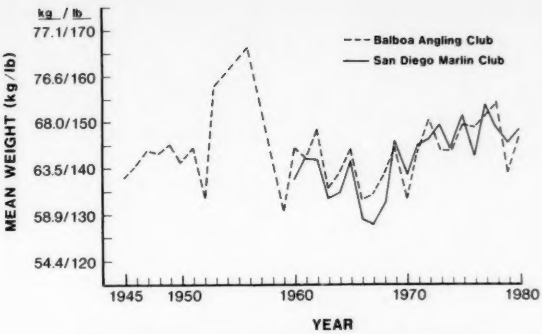

Figure 5.—Mean weight of striped marlin by year for landings at the Balboa Angling Club, 1945-1980 and the San Diego Marlin Club, 1960-1980.

lin. Data indicate that predominantly larger (older) marlin were common to the fishing area in the 5-year period from 1953-57, with marlin of lower mean weight recruited back into the fishery in 1958. From 1958 through 1980 both sets of data (Fig. 5) show no substantial change in average weight even though large catches of striped marlin have been made by the commercial longline fleet in the northeast Pacific.

Acknowledgments

The work of Karen Blakney in reviewing and tabulating recordbook data and preparing length frequency graphics for analysis is appreciated. The manuscript was reviewed by Norman Bartoo and Earl Weber and their suggestions are appreciated.

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NMFS, Coast Guard Strengthen Lacey Act Enforcement

The U.S. Coast Guard and the National Marine Fisheries Service are continuing their vigorous enforcement of the Lacey Act Amendments of 1981 in the Gulf of Mexico. Between October 1982 and June 1983, 50 criminal misdemeanor warrants and six felony arrest warrants were issued by the Federal court in Brownsville, Tex., for masters of vessels charged with violating the Lacey Act Amendments of 1981 (see box).

But despite these enforcement efforts, there have been continuing violations of the Lacey Act. In addition, many shrimp vessels are obscuring or removing their vessel documentation numbers which is a violation of the Magnuson Fishery Conservation and Management Act and the regulations governing the Gulf of Mexico shrimp fishery.

The Coast Guard and NMFS are concerned that past efforts to enforce U.S. laws in the Gulf of Mexico have not had a deterrent effect, and as a result, put a more stringent enforcement policy into effect. Both owners and masters of vessels cited for a violation of the Lacey Act will face a civil penalty of $10,000 and forfeiture of the entire catch on board the vessel. For aggravated circumstances, criminal sanctions of up to $20,000 plus 5 years in prison may be applied. Owners and masters of vessels which are not displaying properly the vessel documentation numbers will be subjected to a civil penalty of up to $25,000.

Later in June, Federal and Texas law enforcement agents boarded more than 45 U.S. shrimp vessels off the south Texas coast, seizing about 16,000 pounds of an allegedly illegal catch worth over $60,000, according to Jack Brawner, NMFS Southeast Regional Director.

The boardings, which took place between 23 and 26 June, revealed over 30 vessels illegally fishing in Mexican waters and about 20 vessels which were apparently trying to avoid identification by blocking out the vessel documentation numbers. In addition, agents allegedly found illegal aliens aboard the shrimp vessels.

The enforcement operation was a coordinated effort by the U.S. Coast Guard, Texas Parks and Wildlife Department, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and U.S. Customs Border Patrol, to enforce the Texas shrimp closure and implement the new Lacey Act enforcement policy which holds the owner and operator of a vessel responsible under the Lacey Act.

The Lacey Act

In part, the Lacey Act, as amended by Congress in 1981, provides that it is illegal to possess, transport, or acquire any fish or wildlife taken in violation of the laws of another state or country. If fish or shrimp are caught in foreign waters in violation of foreign law, it is illegal to possess that catch on board a U.S. vessel, to bring it back to the United States, or to buy or sell that catch in the United States. Lacey Act violations may result in civil penalties up to $11,000 and forfeiture of the catch.

The Gulf of Mexico shrimp fishery regulations, implemented under the Magnuson Fishery Conservation and Management Act, require that:

1) All U.S. vessels' documentation numbers must be displayed on the port and starboard sides of the deckhouse or hull and on an appropriate weather deck to be clearly visible from enforcement vessels and aircraft.

2) The numbers must be in block arabic numerals in contrasting color to the background.

3) For fishing vessels over 65 feet in length, the numbers must be at least 18 inches high.

4) For smaller vessels, the numbers must be at least 10 inches high.

5) The numbers must be permanently affixed (welded or painted) to the vessel.

6) The operator of each vessel must insure that no part of the fishing vessel, its rigging, or gear obscures the official number in any way.

King Mackerel Commercial Fishery Violations Eyed

A number of search warrants were served on 14 June 1983 by Special Agents of the National Marine Fisheries Service (NMFS) to seafood businesses located from Miami to Ft. Pierce, Fla. The agents collected thousands of records indicating the sale of hundreds of thousands of pounds of king mackerel by commercial fishermen after the 6 May closure of the commercial hook-and-line king mackerel fishery.

The U.S. Magistrate, Southern District of Florida, issued the warrants after federal law enforcement agents documented numerous fishermen violating the closure earlier that month. Fish dealers or processors who purchase, sell, or possess king mackerel illegally taken may be fined up to $25,000.

The king mackerel closure was implemented 6 May when the commercial hook-and-line quota established by the Gulf and South Atlantic Coastal Migratory Pelagic Resources Fishery Management Plan was reached. The closure was effective until 30 June, the end of that fishery season.

Mid-Atlantic, New England Council Members Named

Malcolm Baldrige, Secretary of Commerce, has appointed seven people to the New England and Mid-Atlantic Fishery Management Councils, reports Allen E. Peterson, Jr., Northeast Regional Director of the National Marine Fisheries Service. The appointments became effective on 11 August.

Newly named to the New England Fishery Management Council are: Herbert R. Drake, owner of Drake's Harborside Fish Market, Rye, N.H.; and a member of the State Legislature; Alan D. Guimond, President, Stonington Seafood Products, Point Judith, R.I.; and William A. Lund, Jr., Associate Professor, Department of Marine Sciences, University of Connecticut, Noank, Conn.

The new Mid-Atlantic Fishery Management Council members are: Alfred J. Hurlock, Jr., owner and President, Hurlock Roofing Co., Wilmington, Del.; David H. Hart, retired commercial fisherman, Cape May, N.J.; Harry M. Keene, owner, Bay County Industrial Supply Co., Easton, Md.; and James F. McHugh, consultant, Hampton, Va.

The Fishery Management Councils, established by the Magnuson Fishery Conservation and Management Act of 1976, prepare management plans for the fishery resources within their geographic area. The New England and Mid-Atlantic Fishery Management Councils are two of the nation's eight such councils. Council members are selected from nominees submitted by the governors of the states served by each council.

Embargo on Spanish Yellowfin Tuna Lifted

The embargo on yellowfin tuna products from Spain, imposed by the United States in 1975, was lifted as of 19 July 1983. The 1975 action was taken in accordance with the Tuna Conventions Act of 1950.

The U.S. embargo was imposed 1 November 1975 pursuant to a finding that Spanish fishing vessels were conducting activities contrary to the conservation recommendations of the Inter-American Tropical Tuna Commission (IATTC). The Tuna Conventions Act provides that such embargoes, once imposed, "shall continue until the Secretary of Commerce is satisfied that the condition warranting the prohibition no longer exists..." Since 1 January 1980, the IATTC has had no conservation program in effect for member countries in the eastern Pacific Ocean. Therefore, since that time, Spain's activities have not been contrary to any effective IATTC recommendations. A 1-year transition period and certification referred to in the last sentence of 50 CFR 281.8 does not apply because the species is no longer "under regulation." And, because the action relieved a restriction, the 30-day delayed effectiveness provision of the Administrative Procedure Act does not apply. (Source: Federal Register.)

Pacific Seamount Resources Investigated

Ending a 55-day mid-summer cruise to several central North Pacific seamounts, the NOAA ship *Townsend Cromwell* returned with samples of alfonsin, pelagic armorhead, rudderfish, and orange rockfish for market testing, reports Richard S. Shomura, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory.

The *Cromwell*'s primary mission involved the collection of biological, bathymetric, and oceanographic data from waters over and surrounding several seamounts. Secondary missions, according to Shomura, involved experimental squid fishing with jigging machines and providing logistic support for scientific field camps at several islands within the Northwestern Hawaiian Islands.

The pelagic armorhead trawl fishery—by foreign vessels—over the seamount summits is primarily a night fishery (day catches are typically poor). "This situation held true during trawling operations over the summits of NW and SE Hancock, each of which yielded a good trawl catch of pelagic armorhead," said Robert L. Humphreys, Jr., chief scientist.

Since the inception of the seamount trawl fishery, interest has been primarily focused on the summits. "During this cruise we expanded our exploratory efforts down into the slope area off the edges of the seamount summit. These seamounts typically have slope areas which extend some 6,000 feet or more below summit level," Humphreys noted. Exploratory efforts during the cruise involved handlining down to 3,100 feet and fish trap sets to 3,000 feet.

Humphreys reported that pelagic armorhead were found along the slope areas down to 1,380 feet at NW Hancock and 1,650 feet at SE Hancock. The summits of these seamounts are 840 feet deep. In addition, large alfonsin were found at both seamounts from the summit edge and down over the slope areas to 1,650 feet. "Typically only small alfonsin are caught on top of these summits by bottom trawling," said Humphreys.

Fishery resources on the seamounts were first discovered in 1967 when a Soviet trawler caught large quantities of pelagic armorhead and smaller amounts of alfonsin over the seamount summits. Neither the pelagic armorhead nor the alfonsin are known to occur around the main Hawaiian Islands.

Soon after the 1967 discovery, a Soviet trawl fishery began and in 1969 Japanese trawlers entered into this fishery. During the past 7 years, trawl catches of pelagic armorhead have generally declined. U.S. commercial fishermen have not yet entered this fishery.

During this cruise, investigations were conducted at Nero, SE Hancock, and NW Hancock Seamounts and at two unnamed seamounts designated Seamounts 10 and 11. All are located in the extreme northern region of the Hawaiian Ridge and are included within the U.S. 200-mile Fishery Conservation Zone. Also investigated were the Colshan and Yuryaku Seamounts in international waters.

Humphreys also reported that large alfonsin were found for the first time at unnamed Seamounts 10 and 11 and at

Nero Seamount. Pelagic armorhead were also collected for the first time at Seamount 11.

Darryl T. Tagami, chief scientist during the latter part of the cruise, reported the capture of a large pelagic armorhead specimen at the French Frigate Shoals and a large specimen of a different species of alfonsin at Necker Island.

Seafood Preservation and Sodium Labeling

In 1982, the Food and Drug Administration (FDA) proposed regulations that would require the sodium content of food to be included on the nutritional label, if used on a specific product. In June 1983, at the 43rd meeting of the Institute of Food Technologists, one of the best attended sessions was on the "Implications of Reduced Sodium Usage in Muscle Foods." The session was in response to the increased public and regulatory interest in the sodium/salt consumption in the American diet.

John Wekell of the NMFS Northwest and Alaska Fisheries Center's Utilization Research Division (URD) presented a paper at the session titled "Implications of Reduced Sodium Usage and Problems in Fish and Shellfish," discussing two aspects of the proposed FDA regulations that would severely impact the fishing industry: 1) Variability and 2) proposed labeling descriptions under the proposed regulation—the sodium content declared on the label could not be exceeded by more than 20 percent. The URD survey of sodium content in canned fishery products found that about 25-30 percent of the canned tuna and salmon would fail to meet this requirement if the mean of the lot were used. Coefficients of variability were very high (e.g., 45 percent). The industry could overcome this by declaring higher sodium levels, but this would probably lead to depressed sales. In addition, the regulations would provide definitions for terms such as "low sodium," "moderately low sodium," and "sodium free." Using these definitions, fresh fillets could only be labeled as a "moderately low sodium" product. Such a description would overshadow other positive aspects of fish (i.e., high quality protein, low fat, excellent source of trace minerals, vitamins, and essential fatty acids).

While variability of sodium content can be tightened by careful control of salt to the can, the major source of the variation (up to 50 percent) is caused by the use of refrigerated seawater (RSW) systems and the use of high salt brine (23 percent) freezing. Since these processes contribute significant sodium to the final product, any reduction of added salt to the canned fishery product will exacerbate the apparent sodium variability. Reverting back to the ice-chilling systems in place of these two processes is not practical in our current long-distance fisheries such as tuna and salmon.

The proposed new regulations present a dilemma to the fishing industry. If the industry were to abandon its current RSW and brine freezing methods and either adopt new refrigeration methods or revert back to a traditional ice technique, substantially increased costs of operation could be encountered. On the other hand, if the industry does nothing, it risks compliance with the new regulations and consumer resistance to its products.

John C. Wekell

Sorbate Preservation of Cod Is Studied

A preliminary experiment to determine the shelf life of fresh-caught and drawn cod dipped in potassium sorbate is underway at the Northeast Fisheries Center's Gloucester Laboratory. For this work, 200 pounds of market cod, all caught in the same tow of a Gloucester, Mass., fishing boat, were eviscerated and washed. Half was dipped in 5 percent potassium sorbate in seawater and the other half was designated the nondipped control. Both lots were then iced down in boxes and transported to the laboratory at the end of the trip.

Organoleptic tests were conducted on both lots of iced fish, both whole and cooked fillets, to determine their acceptable shelf life. Acceptable shelf life ended when any quality attribute average fell below 5.0 (borderline) on a raw or cooked evaluation 9-point scale.

The acceptable shelf life of whole iced, nondipped cod was 8-9 days while that of the dipped-at-sea (KS) cod was 16-17 days. The acceptable shelf life of the fillets cut from the nondipped cod was 13-15 days while the fillets from the dipped fish lasted 17-18 days. Our panelists commented that the odor of the gill cavity of the sorbate dipped fish was unfamiliar to them; it was not like the usual fish spoilage odor.

This preliminary experiment showed that dipping whole fish in potassium sorbate immediately after being caught and eviscerated did have a beneficial effect on extending shelf life. The experiment will be repeated at least twice.

Burton L. Tinker

Oxidizing Agents Tested With Frozen Red Hake

A new study to test the effects of some oxidizing agents on stabilizing the texture of frozen red hake, *Urophycis chuss*, has been initiated by the NMFS Northeast Fisheries Center's Gloucester Laboratory. They had previously determined that gaseous oxygen, hydrogen peroxide, and sodium hypochlorite were all effective in inhibiting the enzymatic degradation of trimethylamine oxide to dimethylamine and formaldehyde. In this latest experiment, either hydrogen peroxide, sodium hypochlorite, or potassium bromate was added to minced red hake muscle at four different concentrations ranging from 0.01 to 0.25 percent by weight.

After four weekly sampling periods at 10°F storage, a clear trend began to develop. All oxidizing agents were inhibiting the production of dimethylamine and formaldehyde, but samples treated with either hypochlorite or bromate seemed to be tougher (higher shear force) than the control sample. Samples treated with peroxide were not significantly tougher than the control, but they did have lower contents of dimethylamine and formaldehyde. An additional study has been initiated to examine the efficacy of hydrogen peroxide in greater detail.

Joseph J. Licciardello

Fish Product Exports to Korea, 1978-82

Korea (ROK) is the second most important Asian market, after Japan, for U.S. fishery products. U.S. fishery exports to Korea increased from 5,500 metric tons (t) in 1978 to 11,100 t in 1982, an increase in quantity of over 100 percent.

Fishery exports to the ROK increased in value from US$7 million in 1978 to $21 million in 1982, an increase of 192 percent. Most of the increase in the quantity exported occurred in 1981, while a substantial increase in the value of exports occurred in 1980.

Major commodities which the U.S. exported to Korea in 1982 were frozen fish, fish roe, and cured fish. Frozen fish exports, mostly herring and salmon, were worth $15 million, or over 70 percent of the total 1982 U.S. fishery exports to Korea. Fish roe shipments totaled over $3 million (16 percent of 1982 shipments), and consisted largely of herring roe. Cured fish exports to Korea were $2 million, 10 percent of 1982 shipments.

While U.S. fishery exports have increased significantly since 1978, such exports decreased in quantity and value during 1982. Fishery exports to Korea in 1982 declined by 10 and 18 percent respectively from 1981 shipments. Declining U.S. frozen sockeye salmon shipments to Korea accounted for most of the decrease in 1982. Observers believe that the decrease in salmon shipments to Korea in 1982 resulted from the strong U.S. dollar and an economic recession in Korea.

The value of U.S. fishery exports to Korea was an all-time record high $27 million in 1980 due to large 1980 shipments of high-priced fish roe. The all-time record in terms of quantity was set in 1981, when 12,300 t, mostly frozen fish, were exported to Korea.

Korean Importers

The National Marine Fisheries Service's Southeast Regional Office has done considerable work assessing the Korean market. A list of Korean companies which have recently expressed an interest in U.S. fishery products can be obtained from: Jim Ayers, NMFS, NOAA, 11215 Hermitage Road, Little Rock, AR 77211.

Marketing Reports

Several marketing reports have also included an assessment of the Korean market. These include:

1) Handbook for Exporting Seafoods to the Orient, 1979: DIB 80-07-016, $10.

2) Buyer Contacts Made at USDA Red Meat, Poultry, and Fish Exhibit held in Japan, Korea (ROK), and Hong Kong: DIB 80-07-402, $7.

3) Gateway to Oriental Markets: DIB 80-10-011, $10.

4) Market Brief (ROK): Fishing Equipment, 1978: DIB 78-11-012, $7.

5) Recent Trends in Fisheries in Korea, 1978: DIB 79-03-007, $7.

6) Harbor, Dockside, and Marine Equipment, 1979: DIB 80-05-504, $11.

These reports can be obtained by order number for the above prices from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

Marketing Assistance

U.S. companies wishing assistance in exporting fishery products should contact the following NMFS Regional Marketing Offices: Northeast Region, Paul Earl, Chief, Utilization and Development Branch, NMFS, P.O. Box 1109, Gloucester, MA 01930-5309. Telephone (617) 281-3600 ext. 249; Southeast Region, Henry McAvoy, Chief, Commercial Development Services Branch, NMFS, 9450 Koger Blvd., Duval Bldg., St. Petersburg, FL 33702. Telephone (813) 893-3272; Northwest Region, Linda Chaves-Michael, Marketing and Development Branch, NMFS, 7600 Sand Point Way, N.E., Bin C15700, Seattle, WA 98115. Telephone (206) 527-6117; Alaska Region, Carl Rosier, Chief, Fishery Development and Marketing Services, NMFS, P.O. Box 1668, Juneau, AK 99802. Telephone (907) 586-7224.

U.S. Shark Markets Listed

A study of U.S. shark markets has been completed at the Southeast Region of the National Marine Fisheries Service. Copies are available from: Virginia Slosser, National Marine Fisheries Service, NOAA, 9450 Koger Boulevard, St. Petersburg, FL 33702 or telephone (813) 893-3384.

Part of Tortugas Area Opened to Shrimping

Part of the Tortugas Shrimp Sanctuary north of Key West, Fla., was temporarily opened to shrimp trawling between 15 April and 14 August. Scientists studied shrimp migrations through the area while the 44-mile section near Smith Shoal was open.

Some shrimp fishermen claim that many of the shrimp in the sanctuary are permanently lost to the fishery because they move out of the sanctuary to untrawlable bottoms and thus cannot be harvested. However, other fishermen and biologists say there is strong evidence that the shrimp in the sanctuary are too small to harvest, but, as they grow to harvestable size, they migrate and eventually enter the fishing grounds outside the sanctuary.

To determine the facts of the issue, the Gulf of Mexico Fishery Management Council requested that the National Marine Fisheries Service open a section of the sanctuary temporarily to shrimping under a provision of the Council's shrimp fishery management plan.

NMFS biologists conducted shrimp tagging studies in the sanctuary and gathered information on tagged shrimp recovered by commercial shrimpers in the newly opened area to help map the movement of the shrimp.

Reward for Tagged Lobsters

The National Marine Fisheries Service is offering a $5 reward, plus the current landed value, for specially tagged lobsters in the Gulf of Maine. The NMFS began tagging on 5 July within a 40 n.mi. radius of Truxton

Swell in the central Gulf of Maine. The tagged lobsters could be recaught anywhere in the Gulf.

Each tag is a short length of bright orange tubing attached to the base of the lobster's back. One side of each tag has a tag number and the word "REWARD"; the other side has the words "NMFS, WOODS HOLE, MA." Fishermen who catch any of these tagged lobster should: 1) Record the tag number, catch date, and catch location; 2) keep the lobster alive or frozen with the tag intact; and 3) upon returning to port, notify the nearest NMFS port agent for immediate payment.

This tagging study is a joint effort between the State of Maine's Department of Marine Resources and the NMFS's Northeast Fisheries Center. The study will last 3 years, release 1,000 tagged lobsters each year, and yield information on lobster abundance, health, growth, reproduction, and migration.

The Department of Marine Resources and the NMFS Northeast Fisheries Center have begun this study because central Gulf of Maine lobsters are not yet fished as heavily as those along the coast, and because they may be an important source of larvae, or "seed," for replenishing the coastal population. The results of this study should reveal any potential effects of increased fishing for the central Gulf population upon the valuable coastal fishery. For more information contact Thomas L. Meyer at (617) 548-5123.

Butterfish Harvests Could Increase

The butterfish, *Peprilus triacanthus*, is currently one of the most interesting and important species in the southern New England area. Increased abundance and strong markets in Japan stimulated the U.S. fishing industry to take the highest catch of butterfish ever in 1982 (over 8,000 metric tons (t)). The catch would have been even higher if U.S. fishermen had located more concentrations of butterfish.

Butterfish distribution is related to temperature and they are more spread out when temperatures are warm. In addition, butterfish concentrations are found in deep waters off the mid-Atlantic at depths often greater than 100 fathoms in winter. Recent assessments indicate that the butterfish population has just reached record abundance levels and is now beginning to decline.

From 1920 to 1962 butterfish were harvested only by the United States, but in very small amounts. The Soviet Union began harvesting butterfish in 1963 and Japan entered the fishery in 1967, taking butterfish as a by-catch in their squid fishery. From 1968 to 1976, the reported landings averaged nearly 12,000 t per year. In 1973, butterfish landings peaked at slightly less than 20,000 t with over 90 percent taken by foreign nations, primarily by Japan in connection with its squid fishery. The U.S. catch increased over 70 percent from 1981 to 1982, and it is believed that a great deal more butterfish could be taken in 1983 and 1984 without overfishing.

New Export Brochures

The U.S. Department of Commerce's International Trade Administration has prepared two brochures of interest to U.S. fishery exporters. These brochures contain descriptions of services available to help U.S. exporters and a guide to various publications on the mechanics of exporting.

Single copies of these brochures may be obtained by requesting the "Export Bibliography" and the "Commerce Export Assistance Programs: USA Exports" in writing from: International Trade Publications, Room 1617, ITA, DOC, Washington, DC 20230.

Seafood Seasonality Chart Available

A seafood seasonality chart has been developed in a joint effort by the West Coast Fisheries Development Foundation and the National Marine Fisheries Service in Seattle, Wash. The chart, 18×24 inches, lists the month-by-month availability of all the major finfish and shellfish off the coasts of California, Oregon, Washington, and Alaska, and designates the harvesting areas and the common market forms for each species.

This information, displayed in a colorful graph format, is printed on a special moisture- and tear-resistant polypropylene material. Copies of the chart ($1.00 each or 10 for $7.50) may be ordered from the West Coast Fisheries Development Foundation, 812 Washington, S.W., Suite 900, Portland, OR 97205.

Top Buyers of U.S. Seafood Products

Early figures indicate that Japan ranked first as a buyer of U.S. seafood products in 1983 (January-April), spending $75,866,000, distantly followed by Canada at $31,520,000 and the United Kingdom at $22,337,000. The top 15 purchasers for that period (in millions of dollars) are as follows:

1.	Japan	$75.9
2.	Canada	31.5
3.	U.K.	22.3
4.	France	11.9
5.	Rep. of Korea	11.3
6.	Netherlands	9.2
7.	Mexico	8.0
8.	Australia	4.1
9.	China (Peking)	4.0
10.	Belgium and Luxembourg	3.8
11.	Portugal	3.3
12.	China (Taiwan)	3.3
13.	West Germany	3.0
14.	Sweden	2.4
15.	Italy	2.2

Food Show Report Out

The NMFS Northeast Region's Utilization and Development Branch participated in two Middle East food shows early this year: In Manama, Bahrain, and in Riyadh, Saudi Arabia. The results of these seafood missions, indicating export opportunities in these areas, may be requested by U.S. firms. Ask for the Saudi-83 Report from the Branch at P.O. Box 1109, Gloucester, MA 01930 or telephone (617) 281-3600, ext. 212.

Japan's Fisheries Catch Sets New Record in 1982

Japan's 1982 fisheries catch totaled a record 11,414,000 metric tons (t), according to preliminary statistics released by the Japanese Ministry of Agriculture, Forestry, and Fisheries. The harvest was the largest in the world and represented a 1 percent increase over the 1981 catch of 11,319,000 t (Table 1).

Japan has successfully maintained its fisheries catch above 10 million t since 1979, when many other distant-water fishing countries were reporting declining catches. The primary reason for Japan's success has been its rapidly expanding sardine fishery. While this has enabled Japanese fishermen to report increases in the quantity of fish caught, the relatively low value of sardines has affected the value of Japan's fisheries catch.

Marine Fisheries

Japan's marine fisheries catch increased by about 1 percent to 11.2 million t and accounted for about 98 percent of the total 1982 catch. This increase in the marine fisheries catch was achieved despite decreases in the catch from distant-water fisheries and marine aquaculture. Increased catches from the offshore and coastal fisheries easily offset the losses in the other two sectors of marine fishing.

The decreasing distant-water catch reflects the continued effect of the establishment of the 200-mile fishery zones by many countries and the imposition of catch quotas on Japanese fishermen. Japan, however, appears to have at least slowed the rapid decline of its distant-water fisheries catch. The rate of decline in the distant-water catch, as high as 20 percent in 1978, was only 4 percent in 1982 when distant-water catch was actually slightly higher than in 1979.

Inland Fisheries

Japan's inland fisheries catch comprises only about 2 percent of the total catch. The total inland catch increased by 1 percent in 1982 despite a 2 percent decrease in the freshwater catch. A 4 percent increase in freshwater aquaculture offset the decline.

Table 1.—Japan's fisheries catch, 1979-82, by major fisheries.

Fishery	Harvest (1,000 t) 1979	1980	1981	1982	Percent chg.[1]
Marine					
Distant water	2,066	2,167	2,165	2,087	−4
Offshore	5,458	5,705	5,939	8,169[2]	N.A.
Coastal	1,953	2,037	2,038		N.A.
Aquaculture	883	992	960	940	−2
Subtotal	10,359	10,901	11,103	11,196	+1
Inland					
Aquaculture	95	94	92	96	+4
Other	136	128	124	122	−2
Subtotal	231	221	216	218	+1
Grand total	10,590	11,122	11,319	11,414	+1

[1]Percentage of change from 1981 to 1982. N.A. = Not available.
[2]Separate data for offshore and coastal fisheries is not available. Source: U.S. Regional Fisheries Attache, U.S. Embassy, Tokyo.

Catch by Species

The three major species landed by Japanese fishermen in 1982 were sardine, pollock, and mackerel. The sardine catch reached 3.3 million t, 8 percent more than in 1981. Sardine, currently the single most important species taken by Japanese fishermen, is of relatively low value and is used mostly for fish meal and fish feed. In the past, the Japanese sardine catch has tended to be cyclical. Japanese biologists disagree on how stable future sardine catches will be and whether the current high catch can be maintained. The mackerel catch declined by 21 percent in 1982 to 0.7 million t. The pollock catch decreased slightly (2 percent) to 1.6 million (Table 2). The Japanese harvest of whales increased by 2 percent in 1982. The 1982 increase partially offsets a 6 percent decrease in the whale harvest in 1981.

Table 2.—Japan's fisheries catch by species, 1979-82.

Species	Catch (1,000 t) 1979	1980	1981	1982	Percent chg.[1]
Sardine	1,817	2,198	3,089	3,321	+8
Pollock	1,551	1,552	1,595	1,570	−2
Mackerel	1,414	1,301	908	718	−21
Squid	529	687	517	548	+6
Tunas[2]	363	378	360	374	+4
Skipjack	347	377	305	303	−1
Salmon	131	123	150	136	−9
Other	4,438	4,506	4,395	4,444	−1
Total	10,590	11,122	11,319	11,414	+1
	--Number of individuals--				%
Whales	4,918	5,191	4,887	4,967	+2

[1]Percentage of change from 1981 to 1982.
[2]Except skipjack.
Source: U.S. Regional Fisheries Attache, U.S. Embassy, Tokyo.

EEC Tariff Duty on Eels Suspended

Due to a shortfall in eel production requirements, the EEC (European Economic Community) has suspended Customs tariff duties on the import of fresh (live or frozen) and chilled or frozen eels. The suspension in the eel tariff duty is effective from 1 July 1983 to 30 June 1984. A first installment for this tariff duty suspension on eel product is 4,050 metric tons.

Brazilian Shrimp Farms Growing

Brazil has eight operating shrimp farms and several new ones are under construction. Only about 1,000 metric tons of shrimp was cultured in 1982, but some observers believe that there will be a spectacular increase in coming years as more and more farms come into production. Some observers also believe that Brazil has the capacity to become the world leader in shrimp culture.

Latin American Markets and U.S. Fisheries Products

Latin America is not yet a major market for U.S. fishery exports. The United States shipped only 20,100 metric tons (t) of fishery products to Latin American countries, worth $46 million, in 1982 (Table 1, Fig. 1). These shipments represented only 5 percent of the 403,400 t exported by the United States worldwide. Many Latin American countries are aggressively expanding their fishing industries and have established high tariffs and other trade barriers to discourage fishery imports. In addition, U.S. companies have not been able to supply the most important product imported by Latin American countries, dried-salted cod.

U.S. fishery exports to Latin America declined in both quantity (Table 2) and value (Table 3) during 1982. The quantity of exports fell by 27 percent and the value by 19 percent. Shipments to the region were adversely affected by the deteriorating economic conditions in Latin America and the strength of the U.S. dollar.

The major reason for the reduced quantity of 1982 exports, however, was developments in two of the most important importing countries, Peru and Mexico. U.S. exports to Peru declined because improved 1982 catches allowed Peruvian companies to increase domestic fish oil production so that imports from the United States were not needed. Peruvian fishermen not only caught more fish in 1982, but the oil content of the anchovies, the most important species, was unusually high.

The Peruvian situation, however, altered sharply beginning in September 1982 when the sea temperature off northern Peru began to rise as part of the 1982-83 El Niño phenomenon. As a result, both catch and oil content began to decline in the last quarter of 1982. Exports to Mexico declined sharply because a smaller quantity of U.S. shrimp was trucked across the border for processing in Mexican packing plants. (The U.S. Census Bureau counts these shipments as exports even though the shrimp is shipped back to the United States.)

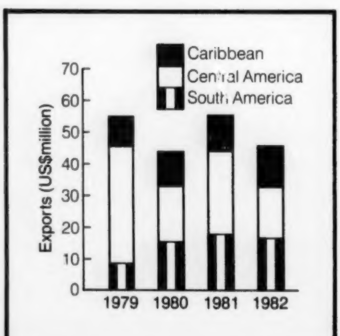

Figure 1.—Latin American fishery imports from the United States, by region and value, 1979-82.

Table 1.—U.S. fishery exports by continental region, quantity, and value, 1981-82.

	Quantity (1,000 t)		Value (US$10⁶)	
Region	1981	1982	1981	1982
Asia	153.4	189.3	596.1	637.8
Western Europe	189.0	146.5	286.9	198.3
North America	52.0	35.9	147.3	117.3
Latin America	27.7	20.1	56.7	46.0
Oceania	5.6	4.0	24.5	14.2
Africa	24.4	6.1	17.9	4.2
Middle East	1.9	1.5	5.0	6.7
Total[1]	454.3	403.4	1,134.4	1,024.6

[1]Totals may not agree due to rounding. The data in this table has been computed for comparative purposes to correspond to the fishery commodity data compiled by FAO. It included edible fishery products, fishmeal, and fish oil.
Source: Bureau of the Census, U.S. Department of Commerce.

The reduced value of export shipments in 1982 was caused by declining purchases in several different countries. The single most important decline was in frozen shellfish which fell from $22.9 million in 1981 to only $16.4 million in 1982 or by 28 percent. Important but smaller declines were reported in frozen and canned fish.

Latin America imports primarily frozen fish and shellfish from the United States. These two commodities in 1982 totaled $33.9 million or over 70 percent of the total $45.9 million worth of U.S. fishery products shipped to the region (Tables 4 and 5, Fig. 2). In terms of quantity, frozen fish was the leading export commodity, but in terms of value frozen fish was only slightly more important than frozen shellfish. Other products with export shipments exceeding $1 million were fish oil, canned fish, and cured fish.

Latin American imports of U.S. fishery products are about evenly divided by area among South American, Central American, and the Caribbean countries (Fig. 1). Only a small number of countries, however, were statistically significant. In South America the only important market for U.S. fishery products was Venezuela. In Central America it was Mexico, and in the Caribbean it was the Netherlands Antilles and Bermuda (Fig. 3).

Venezuela

Venezuela was the most active importer of U.S. fisheries products. U.S. shipments totaled 8,500 t valued at $15.3 million in 1982. Venezuela imported a

Table 2.—Latin America's fishery imports from the United States, by quantity, 1979-82.

Country or dependency	Imports (1,000 t) 1979	1980	1981	1982	Major commodity
Caribbean					
Bahamas[1]	0.5	0.4	0.5	0.3	Canned fish
Barbados	0.1	Negl.	0.1	0.1	Frozen fish
Bermuda[1]	0.4	0.8	0.5	0.6	Frozen fish
British Virgin Isl.	0.2	0.3	0.2	0.5	Other fish
Cayman Isl.	Negl.	Negl.	Negl.	0.1	
Dominican Rep.	1.3	1.9	1.8	1.6	Fishmeal
Fr. West Indies	0.2	0.2	0.3	0.3	Frozen fish
Haiti	Negl.	Negl.	Negl.	0.1	
Jamaica	Negl.	0.1	0.1	0.7	Frozen fish
Neth. Antilles	0.9	0.8	0.7	1.0	Frozen fish
Trinidad-Tobago	Negl.	0.1	0.3	0.5	Canned fish
Turks & Caicos	Negl.	Negl.	Negl.	Negl.	
Subtotal[2]	3.6	4.6	4.5	5.8	
Central America					
Belize	Negl.	Negl.	Negl.	Negl.	
Costa Rica	Negl.	Negl.	0.1	Negl.	Fishmeal
El Salvador	0.1	Negl.	Negl.	Negl.	
Guatemala	Negl.	0.2	0.2	Negl.	Sardines
Honduras	Negl.	Negl.	0.2	0.1	Sardines
Mexico[3]	7.2	5.4	6.6	4.4	Shrimp
Panama	0.2	0.8	Negl.	0.4	Canned fish
Subtotal[2]	7.5	6.4	7.1	4.9	
South America					
Argentina	0.1	Negl.	Negl.	Negl.	
Bolivia	Negl.	Negl.	Negl.	Negl.	
Brazil	Negl.	Negl.	Negl.	0.1	
Chile	Negl.	Negl.	Negl.	0.1	
Colombia	9.8	2.1	0.1	0.2	
Ecuador	Negl.	0.1	Negl.	0.4	
Paraguay	Negl.	Negl.	Negl.	Negl.	
Peru	0.1	12.3	4.9	Negl.	Frozen squid
Suriname	0.1	Negl.	0.1	Negl.	Sardines
Uruguay	Negl.	Negl.	Negl.	Negl.	
Venezuela	3.4	5.4	10.0	8.5	Frozen fish
Subtotal[2]	13.5	19.9	15.1	9.4	
Grand total[2]	24.6	30.9	26.7	20.1	

[1]These islands are not physically located in the Caribbean, but are included in the Caribbean totals for organizational simplicity.
[2]Totals may not agree due to rounding.
[3]Most of the U.S. shrimp "exported" to Mexico is trucked across the border for processing and then shipped back to the United States.
Note: The data in this table has been computed for comparative purposes to correspond to the fishery commodity data compiled by FAO. It includes edible fishery products, fishmeal, and fish oil.
Source: Bureau of the Census, U.S. Department of Commerce.

Table 3.—Value of Latin America's fishery imports from the United States, 1979-82.

Country or dependency	Year 1979	1980	1981	1982	Major commodity
Caribbean					
Bahamas[1]	1.5	1.3	1.5	0.8	Canned fish
Barbados	0.3	0.2	0.2	0.2	Frozen fish
Bermuda[1]	1.9	2.7	2.7	3.0	Frozen fish
British Virgin Isl.	0.5	0.6	0.6	0.8	Other fish
Cayman Isl.	0.2	0.3	0.3	0.2	Shellfish
Dominican Rep.	1.2	1.5	1.6	1.0	Fishmeal
Fr. West Indies	0.4	0.4	0.7	0.6	Frozen fish
Haiti	Negl.	Negl.	Negl.	0.2	Canned fish
Jamaica	0.1	0.3	0.2	1.1	Frozen fish
Neth. Antilles	3.3	3.3	2.9	4.0	Frozen fish
Trinidad-Tobago	0.3	0.4	1.0	1.4	Canned fish
Turks & Caicos	Negl.	Negl.	Negl.	Negl.	
Subtotal[2]	9.7	11.1	11.8	13.3	
Central America					
Belize	0.2	0.1	Negl.	Negl.	Canned fish
Costa Rica	0.1	Negl.	Negl.	Negl.	Fishmeal
El Salvador	0.1	Negl.	Negl.	Negl.	
Guatemala	0.1	0.3	0.5	0.1	Sardines
Honduras	0.1	Negl.	0.3	0.2	Sardines
Mexico[3]	35.7	16.1	24.3	14.8	Shrimp
Nicaragua	Negl.	Negl.	Negl.	Negl.	
Panama	0.7	1.0	0.9	0.9	Canned fish
Subtotal[2]	37.0	17.5	26.0	16.0	
South America					
Argentina	0.2	Negl.	Negl.	Negl.	
Bolivia	Negl.	Negl.	Negl.	Negl.	
Brazil	Negl.	0.1	Negl.	0.5	
Chile	Negl.	0.1	0.1	0.5	Fish roe
Colombia	4.1	1.1	0.2	0.2	Frozen squid
Ecuador	Negl.	Negl.	Negl.	Negl.	
Paraguay	Negl.	Negl.	Negl.	Negl.	
Peru	Negl.	5.3	2.1	Negl.	Frozen squid
Suriname	0.1	0.1	0.2	0.2	Sardines
Uruguay	Negl.	Negl.	Negl.	Negl.	
Venezuela	4.1	7.9	15.3	15.3	Frozen fish
Subtotal[2]	8.5	15.5	17.9	16.7	
Grand total[2]	55.1	44.1	55.7	46.0	

[1]These islands are not physically located in the Caribbean, but are included in the Caribbean totals for organizational simplicity.
[2]Totals may not agree due to rounding.
[3]Most of the U.S. shrimp "exported" to Mexico is trucked across the border for processing and then shipped back to the United States.
Note: The data in this table has been computed for comparative purposes to correspond to the fishery commodity data compiled by FAO. It includes edible fishery products, fishmeal, and fish oil.
Source: Bureau of the Census, U.S. Department of Commerce.

Table 4.—U.S. fishery exports to Latin America by commodity and value, 1978-82.

Commodity	Exports (US$10[6]) 1978	1979	1980	1981	1982
Fish					
Live				Negl.	
Frozen[1]	4.9	7.8	12.7	20.2	17.5
Canned	3.0	3.5	4.4	5.5	3.9
Cured	0.6	0.9	1.2	1.6	2.0
Roe	0.1	0.1	0.1	0.5	0.5
Other	0.3	0.4	0.4	0.9	0.3
Shellfish					
Frozen[1]	25.5	37.8	16.5	22.9	16.4
Canned	1.0	0.2	0.9	0.5	0.3
Other	0.1	0.1	0.2	0.2	0.2
Fishmeal	0.4	0.4	0.7	0.7	0.7
Fish oil	3.7	4.3	6.5	3.9	4.1
Total[2]	39.6	55.5	43.6	56.9	45.9

[1]May contain small quantities of fresh product.
[2]Totals may not agree due to rounding.
Source: Bureau of the Census, U.S. Department of Commerce.

Table 5.—U.S. fishery exports to Latin America by commodity and quantity, 1978-82.

Commodity	Exports (t) 1978	1979	1980	1981	1982
Fish					
Live				4	
Frozen[1]	2,784	4,805	6,995	11,447	9,169
Canned	1,167	1,452	1,662	1,972	1,509
Cured	246	353	362	473	615
Roe	26	33	22	119	65
Other	104	187	170	364	89
Shellfish					
Frozen[1]	5,631	6,514	3,546	4,465	3,108
Canned	225	61	404	257	102
Other	57	47	77	109	54
Fishmeal	1,463	1,570	3,105	2,674	3,286
Fish oil	8,945	10,042	14,873	5,811	2,038
Total[2]	20,648	25,064	31,216	27,695	20,035

[1]May contain small quantities of fresh product.
[2]Totals may not agree due to rounding.
Source: Bureau of the Census, U.S. Department of Commerce.

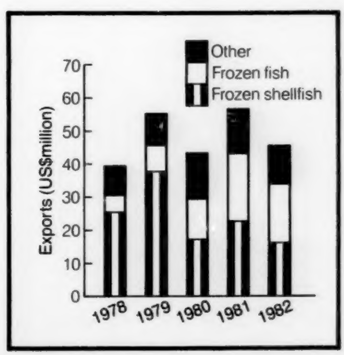

Figure 2.—U.S. fishery exports to Latin America by commodity, 1978-82.

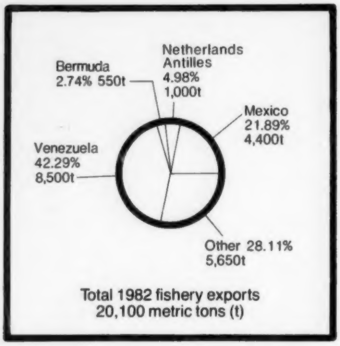

Figure 3.—U.S. fishery exports to Latin America by country, 1982.

variety of different products, the most important being $9.4 million worth of frozen fish (unidentified) and $3.4 million worth of fish oil. Venezuela has sharply increased its imports from the United States since 1978. Beginning in 1982, however, Venezuela experienced increasingly serious financial problems because of a decline in the price of oil, the country's primary export commodity. The value of the Bolivar, once Latin America's strongest currency, fell by more than 50 percent in less than a year. The Government, because of balance of payments problems, then was forced to curtail imports. As a result, the quantity of fish that the U.S. exported to Venezuela declined in 1982, from the record 10,000 t imported in 1981. The value, however, was constant. The Venezuelan Government may be forced to further curtail imports in 1983 and as a result the future market for U.S. exports is unknown.

Mexico

Mexico is the second leading Latin American importer of U.S. fishery products, according to U.S. Customs Bureau data. Shipments in 1982 totaled 4,400 t worth $14.8 million, a decline of 33 percent from 1981 shipments of 6,600 tons. This data is misleading, however, as it includes nearly $11 million worth of shrimp, almost all of which is processed and reexported back to the United States. The remaining $3.8 million worth of fishery products imported from the United States are a variety of products including frozen fish, frozen crab and other shellfish, canned mackerel and sardine, and frozen squid.

Even though Mexico has sharply increased fisheries production in recent years, many observers believe that U.S. exporters could sell substantially larger quantities of seafood if the Mexican Government did not restrict imports. Mexico is already a major market for U.S. agricultural products. Mexico's serious economic crisis, however, will make it difficult to expand exports in the near future.

Netherlands Antilles

The Netherlands Antilles is the third leading Latin American importer of U.S. fishery products. Shipments in 1982 totaled 1,000 t worth $4 million. The most important commodities were fresh and frozen shellfish, but frozen fillets (unidentified) were also important. Unconfirmed reports suggest that some of the imported seafood is not consumed in the Netherlands Antilles, but is reexported to other Caribbean countries.

Bermuda

Bermuda was the fourth leading Latin American importer of U.S. fishery products in 1982. Seafood is imported both for the local population and for tourist hotels and restaurants. Shipments in 1982 totaled 550 t worth $3 million. The most important commodities were frozen fish, shrimp, and other shellfish. (Source: IFR-83/68.)

Peruvian Fisheries Begin to Drop

The Peruvian Ministry of Fisheries reports that the country's fisheries catch totaled only 500,000 metric tons (t) during the first 3 months of 1983, a decline of 28 percent from the 693,000 t taken during the same period of 1982 (Table 1). The decline is almost entirely due to reduced anchovy catches which have been sharply affected by the 1982-83 El Niño phenomenon in the Eastern Pacific. The Peruvian Instituto del Mar also reports that the 1982-83 El Niño is one of the most severe ever reported. The long-term impact on the anchovy stocks is yet to be determined, but some observers believe that the impact on the stocks will be felt for several years. The catch of other species, however, has actually increased.

Most of the Peruvian catch, and almost all of the anchovy is reduced to fish meal and oil. The production of both of these commodities has dropped sharply in early 1983 (Table 1). The particularly steep decline in fish oil production is due not only to the declining anchovy catch, but also to the reduced fat content of the fish which are being caught. Unconfirmed reports from Peru suggest that fish meal and fish oil production in April and May continued to decline.

The reduced fish oil production has created domestic shortages in Peru. The Government has been forced to increase imports of vegetable oils. On 18 May 1983, the import quota for soy oil was almost doubled from 70,000 t to 130,000 tons. The Government is studying an additional request to permit the duty-free importation of 60,000 t of fish oil.

Several U.S. companies experienced stiff competition in 1982 from Peruvian fish oil exporters. During most of 1982 Peruvian fishermen reported excellent anchovy catches of fish with an unusually high fat content. The resulting increased fish oil production enabled Peruvian exporters to compete in markets which had been supplied by U.S. exporters. Declining 1983 production in Peru, however, may enable U.S. exporters to regain lost markets or to export fish oil to Peru itself. (Source: IFR-83/66.)

Table 1.—Peru's fish production statistics, January-March 1982 and 1983.

Item	Amt. (1,000 t) 1982	Amt. (1,000 t) 1983	Percent change
Catch			
Anchovy	414.9	118.2	−72
Other	278.5	381.6	+37
Total	693.4	499.8	−28
Production			
Fish meal	165.2	104.2	−37
Fish oil	41.7	10.1	−76

Source: Peruvian Ministry of Fisheries.

Japan Increases Fishery Imports From U.S. Firms

The U.S. Regional Fisheries Attache for Asia stationed at the U.S. Embassy in Tokyo, Robert Iversen, has prepared a preliminary assessment of Japanese fishery imports from the United States using data published by the Japanese Government. Japan reports importing over 190,000 metric tons (t) of fishery products from the United States in 1982, an increase of 39 percent over 1981 imports. The value of the 1982 shipments was $0.7 billion, only a 6 percent increase over 1981 imports. The United States retained its position as the most important supplier of fishery products to Japan by providing 17 percent of the $4.2 billion worth of fishery products imported worldwide in 1982.

The major commodities which Japan imported from the United States were salmon, and salmon roe, and crab. Frozen salmon and salted salmon roe accounted for nearly 102,000 t worth $465 million, or 65 percent of the total 1982 value of U.S. fishery imports. Japanese salmon imports may decrease slightly in the next 5 years as the Japanese plan to catch 150,000 t off Japan by 1987. This would be a slight increase over the 1982 salmon catch.

Pollock, herring, and squid imports are restricted by Japanese import quotas, but Japan substantially increased imports of all three species in 1982. Ongoing U.S.-Japanese trade negotiations have helped open the Japanese market to U.S. exporters. Japanese 1982 purchases of U.S. frozen pollock nearly reached 16,000 t, a 478 percent increase, valued at $14.8 million. Japanese purchases of frozen squid from the United States totaled about 4,000 t, a 69 percent increase, worth $5.1 million. Japanese 1982 purchases of frozen herring totaled 31,000 t, a 39 percent increase, worth $4.7 million.

Mexican Shrimp Exports to U.S. Increase in '83

The U.S. Regional Fisheries Attache in Mexico City reported that Mexican shrimp exports to the United States were at record levels by mid-summer. Mexican Government statistics indicate that during January-June 1983 Mexican companies exported over $200 million worth of shrimp to the United States, or 25 percent more than during January-June 1982.

The latest U.S. import statistics supported this claim. During January-April 1983, the United States imported $134 million worth of shrimp from Mexico, compared with only $94 million for the same period in 1982. During the entire year of 1982, the U.S. imported 36,365 t of shrimp products from Mexico valued at $375 million.

Ecuadorean Shrimp Exports Increase

Ecuador exported 6,270 metric tons (t) of shrimp to the United States, valued at nearly $60 million during the first 4 months of 1983, an increase of over 50 percent from the 3,970 t exported during the same period of 1982. Reports from Ecuador had suggested that heavy rains, as much as 14 feet in one area, damaged some ponds. Even so, gradually improving yields and the sharply higher trawler catch in the Gulf of Guayaquil kept production at record levels. Some importers, however, reported that much of Ecuador's increased production was smaller-sized shrimp.

Atlantic Mackerel Market Tightens

A shortfall in world supplies of Atlantic mackerel has been forecast by Canada's Department of Fisheries and Oceans, and major exporters of North Sea mackerel (i.e., Norway, Britain, The Netherlands, and the Faroe Islands) are expected to experience a substantial decrease in exports (or possibly none at all) in 1983. Their principal markets for frozen mackerel are Nigeria, Ivory Coast, and Gabon.

Due to a predicted lack of exports of North Sea herring, an extreme shortage of Atlantic herring was also expected to occur during the second half of 1983. France and West Germany are the principal EEC Atlantic herring importers. Both countries are major producers of smoked and canned mackerel. The smoking industries of these countries will be looking for large mackerel, approximately 1-3 pieces/kg to fill their demands. France and West Germany will also require between 20,000 and 30,000 metric tons of frozen round herring. A 10 percent increase in price was expected before the year's end and U.S. salted mackerel fillet prices were expected to remain attractive to foreign importers.

Norway Sees Pollution Problems in North Sea For Important Fisheries

Large amounts of industrial pollutants, oil, and nutritive salts from agriculture and sewage are constantly flowing into the North Sea. In addition, the Norwegian coastal current also receives massive amounts of pollution from the Øresund/Kattegat area, from the east coast of England, the Channel, and the Helgoland Bight. Non-migrating stocks of fish, demersal fauna, and shellfish, as well as fish and mussel farms receive large amounts of polluted water which they cannot escape. In this manner, environmental poisons are brought into circulation in Norwegian food and the whole Norwegian environment, according to Norwegian researcher Morten Laake.

Laake holds that it is high time to initiate an "acid rain" project for the ocean areas too, similar to the ones which have been carried out for Norwegian land areas. Laake believes that the extensive algae growth observed in recent years should be taken as a serious warning. Although this growth is not in itself the result of pollution, it is an indication that nature's own controlling mechanism has been put out of function.

Morten Laake indicated that the North Sea can experience the same problems as those registered in the Mediterranean and the Baltic Seas, if developments in these areas are not heeded. He stated that the time has come for an international plan of action for the battle against pollution in the North Sea. (Source: Norwegian Information Service.)

Texas' Brown Shrimp and 1983-84 Indices

National Marine Fisheries Service scientists have concluded that the brown shrimp season off Texas will be poor and the catch for July 1983-June 1984 is expected to be about 17.8 million pounds, with a range between 16.0 and 19.4 million pounds. All of the 1983 indices point in the same disappointing direction—lower than 1982 and lower than their historical averages.

In the Gulf of Mexico, brown shrimp postlarvae enter the bays and passes when they are between ¼- and ½-inch in length. Collections of young postlarval brown shrimp from the Galveston, Tex., entrance are used as an early indicator of the upcoming crop for the offshore fishery. Shrimp abundance is measured as the postlarvae grow into juveniles and enter the bay and bait shrimp fisheries.

Indices of the abundance of brown shrimp postlarvae and juveniles in the bay are sampled by a unique drop sampling method while they are in vegetated marsh areas. Although no historical data are available from this sampling technique, it is believed that it may be a good basis for predicting the future of brown shrimp crops. Drop sampler data from Galveston Bay are available tor 1982 and 1983, and for the first time scientists are using these density estimates as an additional indicator of the brown shrimp crop. NMFS scientists at its Southeast Fisheries Center Galveston Laboratory primarily use the relative abundance of brown shrimp caught by the Galveston Bay bait shrimp fishery as the most reliable means of predicting the brown shrimp season.

These indices of postlarval and juvenile abundance are based on information collected from Galveston Bay from February through 10 June which is believed to provide a reasonable forecast for the entire Texas coast. Supplementing these indices are additional measures of relative abundance from the brown shrimp inshore fisheries in Matagorda, Aransas, San Antonio, and Galveston Bays.

Postlarval Brown Shrimp Index—Galveston Bay

Mass movements of postlarval brown shrimp into nursery areas usually occur after water temperatures reach or exceed 60°F. This year, bay waters were generally below 60°F until the first week in April. Low catches of postlarval brown shrimp were observed throughout the spring (Feb.-May) and were much lower than the 15-year average postlarval index for Galveston Bay.

Juvenile Brown Shrimp Indices—Galveston Bay

Sampling of juvenile shrimp with the drop sampler in a salt marsh at Galveston Island State Park indicated much lower densities in March and April 1983 compared with 1982. Late recruitment of juveniles was reflected by high densities in May 1983. Over 70 percent of juveniles in May were less than 30 mm in length and did not move into the primary bay areas and be available to the inshore fishing until late June. The lack of an early crop of juveniles in the salt marsh grass habitat in March-April severely limited the inshore and offshore abundance of brown shrimp in 1983.

Another measure of the abundance of brown shrimp is an estimate of the standing stock of shrimp in Sydnor Bayou, a secondary bay in Galveston Bay. In 1970, an above average brown shrimp year, the standing stock was estimated at 6,500 shrimp per acre; for 1983, the standing stock was estimated at 2,600 per acre.

Texas Inshore Bay Fishery

The Texas inshore brown shrimp season opened on 15 May. Catch rates were relatively low, less than 45 pounds/hour in all bays, especially Galveston Bay where shrimpers concentrated on catching white shrimp in May. Although there are no comparable measures of catch rates from previous years, it is felt that the 1983 catch rates are low; good catch rates from previous years range from 75 to 100 pounds per year.

Bait Shrimp Indices for Galveston Bay

The best estimate of the relative magnitude of the brown shrimp crop comes from data collected from the Galveston Bay bait shrimp fishery during May and early June. This year's index is extremely low and we predict a total catch from July 1983-June 1984 of about 17.8 million pounds, a below average year (i.e., average offshore brown shrimp production for statistical areas 18-21 from 1960-82 was 27.5 million pounds). (Source: SEFC Galveston Laboratory.)

Marine Mammal Biology, Conservation Conference

The Fifth Biennial Conference on the Biology of Marine Mammals, sponsored by The Society for Marine Mammalogy, will be held from 27 November to 2 December 1983 in Boston, Mass., on the conservation of, and recent research on, whales, seals, and other marine mammals. Conference host is the New England Aquarium and the conference headquarters is at the Westin Hotel in Copley Place.

About 1,000 marine mammal specialists from North America are expected to attend, along with many other researchers from around the world. Further information on the conference and The Society for Marine Mammalogy is available from John H. Prescott, Conference Chairman, New England Aquarium, Central Wharf, Boston, MA 02110.

Oregon Shrimp Landings Down 54 Percent From '82

Only 1.0 million pounds of shrimp were landed in Oregon ports last June, a decrease of 69 percent from the 2.9 million pounds landed during June 1982. Season totals for 1983, through June, were 4.5 million pounds compared with 9.7 million pounds through June 1982.

The number of vessels fishing for shrimp also continued to decline, with only 94 vessels making deliveries in Oregon during the period, compared with 109 vessels the previous year. A more significant reduction in effort is seen in the number of deliveries, which declined from 339 during June 1982 to 221 in June 1983. The price fishermen received for their catch ranged from $0.72-0.77/pound, depending on the grade of shrimp and the port or plant to which it was delivered.

Shrimp availability was spotty to nonexistent in almost all areas. Most of the effort had been made in the Mudhole area, but the volume was low. The smallest shrimp continue to come from the Destruction Island area, with an average of 164.9 shrimp per pound.

During April, Oregon shrimp fishermen had landed 2,011,000 pounds of shrimp, a decrease of only 4,000 pounds from the 2,015,000 pounds landed in April 1982. However, 1,263,000 pounds were delivered into Oregon from 16 to 30 April, 33 percent less than the 1,894,000 pounds delivered during this period in 1982. The number of vessels fishing increased by 10, totaling 92 during this period, but which was a decrease of 33 percent from 1982 when 137 vessels were fishing. Fishermen received $0.62-0.72/pound for their catch during this period.

During May fishermen landed only 1.5 million pounds of shimp in Oregon, a decrease of 69 percent from the 4.8 million pounds landed in May 1982. This decline left the season total, through May 1983, at 3.5 million pounds compared with 6.8 million pounds through May 1982.

Only 101 vessels fished for shrimp during May, 55 vessels less than in May of 1982. These vessels made 247 deliveries and were paid $0.70-0.75/pound for their catch. Larger amounts of 1-year-old shrimp began to appear in the catch during May, particularly in area 32 (Destruction Island) where the count averaged 167 shrimp per pound.

Bristol Bay's Sockeye Take Breaks All Records

Alaska's 1983 Bristol Bay commercial harvest of sockeye salmon, *Oncorhynchus nerka*, broke the previous all-time high record catch and also exceeded the record harvest of all salmon species in the bay. More than 36 million sockeye had been harvested by commercial fishermen as of mid-July; the previous harvest record was 25.7 million caught in 1981.

The Bristol Bay fishery, largest sockeye producer in the world, generates about 24 percent of the Pacific Rim production, approximately 48 percent of the United States production, and some 63 percent of Alaska's red salmon production. By mid-July more than 44 million fish had been accounted for in the 1983 Bristol Bay sockeye run. The record run of sockeye to the bay was 63 million in 1980. The unexpectedly high run and harvest of sockeye this year are attributed to such factors as phenomenal fresh water and marine survival coupled with a significant reduction in high seas interception, plus sophisticated management of escapement in past years to ensure returning stocks, according to the Alaska Department of Fish and Game.

TEXAS OYSTERMEN REAP TOP HARVEST

Oystermen along the Texas Gulf Coast harvested an all time record 6.3 million pounds of oysters during the 1982-83 season, according to Texas Parks and Wildlife Department officials. C. E. Bryan, director of shellfish programs, said the estimated $8.4 million dockside value of the catch also was an all-time high. Previous high for the 6-month oystering season was 1965-66, when 4.9 million pounds were brought in, Bryan said. The season usually runs from 1 Nov. to 30 April each year.

As in the past, about 80 percent of the Texas oyster harvest occurred in the Galveston Bay system, where placement of clean oyster shell on 700 acres of the bay in July 1980 was believed to be a factor in the good 1982-83 harvest. Generally favorable environmental conditions on the Upper Texas Coast since 1978 also enhanced oyster reproduction and survival, Bryan noted. The clean shell provided additional habitat for larval oysters (spat) to attach and grow. The shell placement was estimated to have increased the spat set by 1.5 million per acre, he said.

Texas and other Gulf Coast states operate a system of private leases which also increases the total harvest. Under the lease system, oysters from polluted areas can be transported to designated areas and subsequently harvested after being examined by Texas Department of Health officials and declared safe for human consumption. All private leases in Texas are located in Galveston Bay, Bryan said. Other management techniques have been used in recent years to protect the resource, including adjustments of the opening and closing dates of the season. (Source: Texas Parks and Wildlife Department.)

Pacific Mackerel Signs Reported "Encouraging"

The Pacific mackerel season was closed at midnight 23 June, having reached a season quota of 29,000 tons according to landing receipts tallied by California's Department of Fish and Game. The season reopened 1 July with a quota of 22,000 tons.

That quota was recommended by DFG marine biologist Rick Klingbeil of Long Beach who estimated a total biomass of approximately 131,000 tons in his annual legislatively mandated report on the Pacific mackerel status. Klingbeil noted that the age composition of Pacific mackerel samples from April and May 1983 reversed the trend of a fishery dominated by older fish. From

July 1982 through March 1983, the 1978 and older years classes accounted for an estimated 65 percent of the tonnage landed. During April-May 1983 they accounted for 41 percent of the tonnage landed, with 2- and 3-year-olds (1980 and 1981 year classes) accounting for 49 percent.

What this appears to mean, said Klingbeil, is that the trend toward an older population of mackerel seems to be reversing itself, an "encouraging" sign. In his report, Klingbeil noted that sardines had occurred in 67 percent of the sampled mackerel landings in May, and that the cumulative 1983 incidental catch of sardines through the end of May was close to 200 tons. Klingbeil said it was too early, however, to say that the sardine was about to make a comeback. (Source: California Department of Fish and Game News.)

Global Seafood Expo Is Set for Los Angeles

An international seafood exposition, Sea Fare '84, will be held in Los Angeles, Calif., 24-25 January 1984 at the Airport Hilton and Towers. Jointly sponsored by Sea Fare Expositions, Inc., and *Seafood Leader* magazine, it will feature displays of seafood products, associated services, and seminars.

Exhibitors will include seafood producers and distributors who will display a wide variety of fresh, frozen, and processed seafood products from around the world. Seafood buyers from all levels of the food distribution chain (foodservice and institutional buyers; supermarket buyers; restaurant owners, buyers, and chefs; seafood retail market owners; and buyers and foodservice operation managers) are expected to attend.

Sea Fare '84 will feature an extensive program of hands-on seminars to educate seafood buyers about the complexities of seafood and thus improve their profitability. Sample seminar topics include: "How to Sell Consumers on Frozen Seafood," "Seafood Seasons: Knowing When to Buy," "Quality Seafood: Making It Pay," "Product Substitution: How to Spot and Avoid It," and "What a Consumer Looks for in Seafood." For further information, contact project manager Sandi McKenzie, Sea Fare '84, 4016 Ashworth Ave. N., Seattle, WA 98103, telephone (206) 547-6030.

International Artificial Reef Conference Held

The "Third International Artificial Reef Conference" was held at the Registry Hotel in Newport Beach, Calif., on 3-5 November 1983. The conference examined the effectiveness of new technologies in enhancing marine productivity and harvest. Conference sessions included: Siting and reef design criteria, reef development and productivity, surface and midwater fish aggregating devices, productivity of artificial verus natural reefs, mitigation applications, and fishery management considerations. The conference was attended by over 250 persons and the proceedings of it are scheduled for publication at a later date, according to conference organizers.

The conference brought together many of the major researchers concerned with recreational and commercial fishery applications of artificial reef enhancement and fish aggregation from the United States, Japan, China, Australia, Philippines, and many other nations. It also emphasized the need to establish coordination between current and future artificial reef enhancement and fish aggregation research efforts throughout the United States and the world.

FAO Holds International Conference on Fisheries

The U.N. Food and Agriculture Organization (FAO) will hold a World Conference on Fisheries Management and Development, FAO Director-General Edouard Saouma has announced. The two-part conference will be held in Rome.

"This initiative by FAO is the first international step to examine the practical realities of fisheries management in the context of the new legal regime of the seas," Saouma stated. Although it will concentrate on marine fisheries, the World Fisheries Conference will also look at inland fisheries and aquaculture. The first part of the Conference (technical side), in the regular meeting of FAO's Committee on Fisheries, was held 10 to 19 October 1983. The Committee will present its recommendations to the policy phase of the Conference from 27 June to 6 July 1984.

The Conference will discuss the contribution of fisheries to national economic, social, and nutritional goals; the special role and needs of small-scale fisheries and rural fishing communities; international trade in fish and fishery products; and international collaboration in fisheries research and management.

FAO expects the Conference to forge a strategy of fisheries management and development and come up with action programs which will focus on technical assistance, with special emphasis on small-scale fisheries, investment for fisheries development, integrated training, and promotion of intraregional and international trade. The World Fisheries Conference is open to all member nations of FAO, of the UN, and its specialized agencies.

Two Giant Bluefin Tuna Set Texas State Records

Two huge bluefin tuna caught within 2 hours of each other have been certified as state records by the Texas Parks and Wildlife Department. The new record was held briefly by Robert C. Wilson III of Houston when he caught a 640-pounder at 3:30 p.m. on 30 May. At 5:10 p.m., Wilson's guide, Ricky H. Preddy of Port Mansfield, boated an 802-pound bluefin which ousted the first fish from the record book.

Both fish were caught in 300 fathoms depth off the East Breaks, and both anglers were using 130-pound-test line. Preddy's record fish was 114 inches long and 84 inches in girth. A 540-pounder had held the state record since 1977.

Other state records recently certified by the department's fish records committee include a 2.81-pound smooth puffer caught by Judie Holland of Galveston 5 June and a 63-pound, 4-ounce bigmouth buffalo caught by Kelly Arnold of Marshall at Caddo Lake on 21 May.

The Pacific Coast Fishes of North America

The "Peterson Field Guide Series" has long been known for its authoritative and useful handbooks on identifying birds, mammals, wildflowers, seashells, and much more. The latest in this series, "**A Field Guide to Pacific Coast Fishes of North America**," by William N. Eschmeyer, Earl S. Herald, and Howard Hammann, continues that high quality and reliability and fills a considerable regional gap. Its coverage ranges from the Gulf of Alaska to Baja California.

The field guide is obviously intended for general public use and will be excellent reference, but it will also be widely used and appreciated by the scientific community, commercial fishermen, sport fishermen, and scuba divers.

Over 600 species are described in detail and there are over 525 illustrations (with 211 in 22 full-color plates) to aid quick and accurate field identification. The book uses the time-tested Peterson Identification System to group similar species for easy comparison and to note the particular marks that help distinguish species similar in appearance.

Besides the plates (26 black and white, 22 color), the text has an additional 44 numbered figures illustrating important anatomical characters. About 70 percent of the fishes shown in full color are so illustrated for the first time. All fishes found in less than 200 m of water are included, along with many deep-sea species. Names used follow the AFS Special Publication 12, although additional popular names are provided for some species.

Introductory material on fish names, sizes, range, habitat, sex differences, color, and activity patterns and on collecting, observing, and conserving fishes is exceedingly brief. However, the data provided for each order and family are complete and well written and presented. The many species accounts are concise but thorough, providing necessary and current data on identification, range, habitat, similar species and other remarks (often on similarly named or similarly looking species, commercial or sport uses, methods of harvest (if any), value as prey, danger to humans, how marketed or consumed, etc.). Also provided are a glossary, selected references, and an index.

Eschmeyer is Director of Research and Curator of the Department of Ichthyology at the California Academy of Sciences in San Francisco where the late Earl S. Herald was Associate Director of the Steinhart Aquarium. Illustrator is Howard Hammann, though Jon Gnagy contributed 9 of the 48 plates; Katherine P. Smith was Associate Illustrator. The authors have also drawn on scores of other fisheries experts for review, advice, and assistance, and the result is a highly authoritative, useful field guide that will be of great value to people ranging from casual anglers or divers to commercial and sport fishermen and the scientific community.

Published by the Houghton Mifflin Company, Boston, the 366-page volume is sponsored by the National Audubon Society, National Wildlife Federation, and the Sport Fishing Institute. It is available in most bookstores for $11.95 (soft cover) and $19.95 (hard cover) or by mail (tax and postage paid) from the California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118 for $11.00 and $18.00, respectively. Make checks payable to "Field Guides." Foreign mail orders are $2.00 additional.

The Biology and Evolution of Crustacea

Australia's first international conference on Crustacea was held at the Australian Museum in Sydney in May 1980, with more than 160 carcinologists from 15 countries attending. Some 90 papers and posters were presented on crustacean evolution, physiology, community ecology, behavior, biogeography, reproductive biology, and taxonomy.

Twenty of those contributions have now been published in "**Papers from the Conference on the Biology and Evolution of Crustacea**," edited by James K. Lowry, Memoir 18 of the Australian Museum. Copies of the 218-page paperbound volume are available from the Museum in Sydney, New South Wales, at $21.00 each (postage and handling charges not listed).

World Freshwater and Marine Gamefish Records

The year 1982 set a new record for new angling records for the International Game Fish Association (IGFA), owing to their implementation of new light-tackle world record categories for saltwater anglers and to a greater awareness among anglers of IGFA's expanded world record programs. Over 630 new world game fish records were granted last year.

The newest records, plus an update of the listings in all-tackle, line class, and tippet class categories for over 150 freshwater and saltwater species are now included in the IGFA's new "**1983 World Record Game Fishes**." Almost 100 pages of world angling achievements are listed. In addition, the book includes the official international angling rules and world record requirements set by the organization. Equally important are its articles by expert anglers and fishery scientists on topics of interest to serious anglers.

New articles (Section 2) include a discussion of the development of the striped bass freshwater fishery by outdoor writer Vlad Evanoff; an in-depth look at "Sight and Sound Perception in Fishes," plus some excellent under-

water fish photos, is provided by Parry B. Larsen of the University of Miami; Peter Goadby of Australia gives seasoned advice on the setting and enforcing of fishing tournament rules; outdoor writers Mark Sosin and Lefty Kreh discuss tackle and techniques for fly fishing the flats; and Jim C. Chapralis gives tips for traveling anglers.

Section 3 provides a rundown on the angling rules, record requirements, IGFA's annual fishing contest, and its new 5, 10, 15, and 20-to-One Clubs, which recognize anglers for taking fish weighing one of those multiples of the line weight.

Meanwhile, IGFA's Eighth Annual Fishing contest, now underway, provides recognition and documentation for anglers who catch the biggest fish each year, whether they are world records or not. This program emphasizes entries for species not yet listed in the world records to help determine which ones should be considered for the listing and what the heaviest acceptable line class for each new species will be.

Section 4 is the world record listings and Section 5, the 80-page "Guide to Fishes," describes and illustrates all the record species. This data has been revised and expanded with new data on distribution, habitats, fishing methods, food and sporting value, biology, etc. Section 1, of course, relates IGFA's goals, philosophy and programs.

Appendices include listings of the "Game Fish Records of Nations and Continents" as recorded by angling clubs around the world, a revised synopsis of major gamefish tagging programs, a knot-tying guide, an index to common and scientific names of the species, and a directory to state conservation agencies.

With its sound fishing rules, record listings, articles, and game fish species data, the volume is both comprehensive and authoritative and is an excellent reference for both marine and freshwater anglers and conservationists. Copies of the 328-page paperbound volume are available from the publisher, International Game Fish Association, 3000 East Las Olas Blvd., Fort Lauderdale, FL 33316-9987 for $7.95 postpaid (US$9.75 for foreign orders).

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; from the Publications Services Branch (E/AI13), National Environmental Satellite, Data, and Information Service, NOAA, U.S. Department of Commerce, 3300 Whitehaven St., Washington, DC 20235; or from the National Technical Information Service, Springfield, VA 22151. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS SSRF-761. Bretschneider, Dale Emil, and Douglas R. McLain. **"Sea level variations at Monterey, California."** January 1983, iii + 50 p., 16 figures, 3 tables, 2 appendices.

ABSTRACT

Sea level data from Monterey, Calif., 1963 through 1976 were compared with data from coastal stations from Peru to Alaska. Sea level fluctuations at Monterey were correlated with data from these stations, particularly those to the south. The causes of sea level fluctuations at Monterey were investigated by correlation, regression, and spectral analysis of sea level with atmospheric pressure, zonal and meridional wind stress, Ekman and Sverdrup transport, surface temperature and salinity, and dynamic height data from nearby locations. Of these variables, dynamic height was the best predictor of sea level fluctuations. Atmospheric pressure, surface temperature, and meridional wind stress were of secondary importance. The prediction was better during the Davidson Current period than during the upwelling period.

NOAA Technical Report NMFS SSRF-762. Squire, James L., Jr. **"Abundance of pelagic resources off California, 1963-78, as measured by an airborne fish monitoring program."** February 1983, v + 75 p., 65 figures, 4 tables.

ABSTRACT

From September 1962 through December 1978 commercial aerial fish-spotter pilots operating off southern and central California and northern Mexico, maintained a flight log indicating the geographical areas searched and an estimate of the quantity of pelagic species observed. These flight logs were analyzed for quantities of the various species observed per block area (10′ longitude by 10′ latitude area). Flights were recorded as surveying all or a portion of 164,753 block areas. A total of 110,375 block areas were surveyed during the day and 54,378 during night operations. An annual index of apparent abundance (arbitrary values) was computed for each of the major species observed, both for day and night aerial observations from selected geographical areas, and for total observations. The index value computed is not directly comparable between species.

During the period of the survey, the apparent abundance index for Pacific sardine, *Sardinops sagax caerulea*, declined from 1.03 in 1964 to 0.00 in 1974, and no significant schools have been observed by aerial surveys since. The northern anchovy, *Engraulis mordax*, night apparent abundance index remained relatively constant from 1963 to 1969 (2.99-4.35), increased substantially in 1973 to 14.99, then declined by 1978 to a level (1.91) near that observed in 1963-69. The day index for Pacific bonito, *Sarda chiliensis*, declined to a low level in 1968-69 (0.43-0.26), increased in 1972 to 1.11 (a year of above average sea surface temperature), and in subsequent years declined again to a low level (±0.1). Pacific mackerel, *Scomber japonicus*, population biomass was apparently low in 1962 at the start of the surveys, and continued to decline to very low night abundance levels during 1967-75 (undefined range of 0.00 to 0.03). In 1976 a small increase in the overall

apparent index was recorded. By 1977 the night index had increased to 2.62, and in 1978 it again increased to a high level of 7.46. Jack mackerel, *Trachurus symmetricus*, showed a declining abundance index value during 1969-75 (0.66-0.40). A small increase in the night index apparent abundance was noted in 1976, and in 1977 the night index increased to 2.77. In 1978 it then increased about 1.5 times to a record high of 4.20.

Downward trends in apparent abundance indexes were noted 1-2 years in advance of declines in the commercial catches for northern anchovy and Pacific bonito. Limitations of collected nonrandom data and variations in sightings and school size estimation between pilots are discussed. The apparent abundance indexes obtained from aerial surveys are compared with measures from larval and acoustical surveys.

A rank correlation analysis was made to measure the agreement between independent estimates of northern anchovy spawning biomass, larval index, and aerial index. Significant correlations were found for the aerial and acoustical survey indices of 1972-78 for the northern anchovy (r_s = 0.810, significant at the 0.05 level). During this period only three larval surveys were conducted, insufficient to calculate correlation. For earlier data, 1962-66 and 1968-69, larval vs. aerial index gave a poor correlation (+ 0.30). A significant correlation was evident for Pacific mackerel aerial index vs. spawning biomass index (r_s = 1.00).

NOAA Technical Report NMFS SSRF-763. Nelson, Craig S., and David M. Husby. "**Climatology of surface heat fluxes over the California Current region**." February 1983, iii + 155 p., 21 figures, 1 table, 2 appendices.

ABSTRACT

Historical surface marine weather observations are used to compute large-scale atmosphere-ocean heat exchange components over the California Current region. Heat exchange components are summarized by 1° square areas and long-term months, and major features of the monthly distributions are described. The accuracy of the derived air-sea interaction variables and methods of computation are discussed.

The region off the west coast of the United States and Baja California is characterized by net annual heat transfer from atmosphere to ocean. Net oceanic heat gain reaches a maximum during summer off Cape Mendocino. Near the coast, surface heat flux is determined by a balance between incoming solar radiation and effective back radiation. In the offshore regions, high cloudiness reduces the magnitude of the short-wave radiative flux, and latent heat flux produces the largest heat loss. The principal seasonal and spatial variations in air-sea heat transfer are a consequence of coastal upwelling which contributes to relatively low cloudiness and high incident solar radiation near the coast, suppression of evaporative heat loss, and reversal of the sensible heat flux. Simplified heat budget calculations demonstrate the importance of advective processes in maintaining the seasonal heat balance in coastal upwelling regions. Nonseasonal fluctuations are evident in time series of heat exchange processes, but low frequency components are not well described by the surface marine data used in this study.

NOAA Technical Report NMFS SSRF-764. Frost, Kathryn J., and Lloyd F. Lowry. "**Demersal fishes and invertebrates trawled in the northeastern Chukchi and western Beaufort Seas, 1976-77**." February 1983, iii + 22 p., 4 figures, 6 tables, 1 appendix.

ABSTRACT

Thirty-five successful otter trawl tows were conducted in the northeastern Chukchi and western Beaufort Seas in August-September of 1976 and 1977. Nineteen species groups of fishes and 238 invertebrate taxa were identified. Three of the fishes (*Boreogadus saida*, *Lycodes polaris*, and *Icelus bicornis*) accounted for 65 percent of all fishes caught. Information on size, reproductive condition, and food habits is presented for those three as well as for *Artediellus scaber*, *Aspidophoroides olriki*, *Liparis* spp., *Eumicrotremus derjugini*, *Gymnelis viridis*, and *Icelus spatula*. The first Beaufort Sea records are reported for three species: *Arctogadus glacialis*, *Lycodes raridens*, and *Eumesogrammus praecisus*. Of the invertebrate taxa, echinoderms (mainly brittle stars and crinoids) were the most abundant, and in most cases comprised more than 75 percent of the total trawl biomass. West of long. 154° W, brittle stars, *Ophiura sarsi*, were predominant whereas east of long. 150° W, the invertebrate community was characterized by crinoids (*Heliometra glacialis*) and small scallops (*Delectopecten groenlandicus*). Information on size, reproductive condition, and depth distribution is presented for brachyuran crabs and shrimps and the occurrence of other major invertebrate groups is summarized. A complete list of species and stations at which each was caught is included.

NOAA Technical Report NMFS SSRF-765. Haynes, Evan. "**Distribution and abundance of larvae of king crab, *Paralithodes camtschatica*, and pandalid shrimp in the Kachemak Bay area, Alaska, 1972 and 1976**." April 1983, iii + 64 p., 29 figures, 1 table, 3 appendix tables.

ABSTRACT

Distribution and abundance of larvae of king crab, *Paralithodes camtschatica*, northern shrimp, *Pandalus borealis*, humpy shrimp, *P. goniurus*, coonstripe shrimp, *P. hypsinotus*, and sidestripe shrimp, *Pandalopsis dispar*, were studied in the Kachemak Bay area, Alaska, in 1972 and 1976. In both 1972 and 1976, larvae of king crab, northern shrimp, and humpy shrimp first appeared in outer Kachemak Bay; their abundance was greatest in the central portion of the outer bay. Two additional species were studied in 1972, coonstripe shrimp and sidestripe shrimp. In 1972, the center of abundance of sidestripe shrimp larvae was similar to that of larvae of king crab, northern shrimp, and humpy shrimp. Coonstripe shrimp larvae were most abundant in the inner bay and along the northern shore of the outer bay.

The direction in which larvae were transported out of outer Kachemak Bay was only in partial agreement with suspected water-current patterns and may have been influenced by behavior of the larvae. Continued abundance of larvae in outer Kachemak Bay may be caused by entrainment of the larvae in gyres.

Depending on species and area, pandalid shrimp larvae are released at different times and over different periods. For example, larvae of northern shrimp appeared in plankton catches earlier than larvae of humpy shrimp. Coonstripe shrimp had the longest release period of all the shrimp sampled.

From the percentage of glaucothoe in the samples, king crab larvae probably settle in the Bluff Point area in outer Kachemak Bay. Larvae of pandalid shrimp probably settle in outer Kachemak Bay and possibly lower Cook Inlet, but exact locations cannot be determined only by observing changes in morphology of the larvae.

Vertical depth distributions of larvae of king crab and pandalid shrimp were generally similar. Early-stage larvae of king crab, northern shrimp, and humpy shrimp migrated vertically in a diel cycle. A thermocline did not prevent migration to surface waters.

NOAA Technical Report NMFS SSRF-766. Caracciolo, Janice V., and Frank W. Steimle, Jr. "**An atlas of the distribution and abundance of dominant benthic invertebrates in the New York Bight apex with reviews of their life histories**." March 1983, v + 58 p., 69 figures, 5 tables.

ABSTRACT

Distribution, abundance, and life history

summaries are given for 58 important species of benthic invertebrates collected in the New York Bight apex during five sampling cruises in 1973 and 1974. These species showed affinities to major community types that have been previously identified in the Middle Atlantic Bight and some showed varying degrees of tolerance of areas in the apex where the dumping of New York Harbor dredge spoils and New York metropolitan area sewage sludge occurs. *Capitella capitata*, a species often associated with pollution stress, dominated the sewage sludge dump site.

NOAA Technical Report NMFS SSRF-767. Creaser, Edwin P., Jr., David A. Clifford, Michael J. Hogan, and David B. Sampson. "**A commercial sampling program for sandworms, *Nereis virens* Sars, and bloodworms, *Glycera dibranchiata* Ehlers, harvested along the Maine coast**." April 1983, iv + 56 p., 16 figures, 30 tables, 1 appendix.

ABSTRACT

Brief discussions of the history and development of the marine worm fisheries for bloodworms, *Glycera dibranchiata*, and sandworms, *Nereis virens*, the methods of digging both species, the packing media used in their shipment, and the various marine worm markets, are presented.

The status of the commercial marine worm fishery between April and September 1973-76 was investigated. A sampling program for bloodworms and sandworms revealed that there was no significant difference in the mean size of bloodworms (18.72 ± 0.60-20.83 ±0.54 cm) and sandworms (25.69 ± 0.42-26.77 ± 0.53 cm) harvested. Marine worm diggers avoid picking up potential spawning sandworms during the months of March, April, and May and bloodworms during the month of May. During August and September, potential sandworm spawners comprise 15.6-38.3 percent of the commercial catch; during April, potential bloodworm spawners comprise 7.33-13.58 percent of the commercial catch. Sandworm spawners were found coastwide but bloodworm spawners were never collected east of the Taunton River (Sullivan, Maine). Approximately 8 percent of the sandworms and 5-7 percent of the bloodworms had regenerated tails and approximately 19-23 percent of the sandworms and 12-13 percent of the bloodworms were broken.

The use of probability sampling expansions has enabled us to estimate that sandworm diggers dug a total of 45,746-66,004 hours/sampling season during a total of 23,402-31,587 tides/sampling season and landed a total catch of 307,426-409,189 pounds. Bloodworm diggers dug a total of 89,691-177,909 hours/sampling season during a total of 30,545-62,339 tides/sampling season and landed a total catch of 109,936-206,577 pounds.

It cannot be conclusively stated that sandworm and bloodworm abundance changed significantly between 1973 and 1976. Ratio estimates of the numbers of marine worms dug/digger tide varied between 1,024 ± 60-1,184 ± 38 (sandworms) and 536 ± 36-662 ± 26 (bloodworms).

The 6-month mean value/tide and value/hour varied between $27.97-$40.30 and $14.34-$19.15, respectively (sandworms), and $27.97-$31.59 and $10.11-$11.00, respectively (bloodworms).

A significant difference exists in the length-weight relationships for sandworms and bloodworms from eastern Maine and the Sheepscot River. This observation may result from the fact that bloodworm spawners are rare in eastern Maine and bloodworms may substitute an increase in weight for the production of gametes. No explanation for this observation in sandworms can presently be given.

The numbers of bloodworms and sandworms per pound were calculated from mean length and length-weight data. Although the mean number of bloodworms per pound decreased during the 4-year sampling period, the decrease was not signficant at 95 percent confidence limits (1.96 SE). No significant changes in the mean number of sandworms per pound were recorded during the same period.

The MSY (maximum sustainable yield) for the fishery was obtained with approximately 815 bloodworm diggers, 386 sandworm diggers, and 99 diggers who dug both species. OSY (optimal sustainable yield) was approximatley 564-689 bloodworm diggers, 267-327 sandworm diggers, and 69-84 diggers who dug both species. Very rough quotas of 28-33 million bloodworms, and 26-30 million sandworms are associated with these OSY figures.

The overall average frequencies of bloodworm and sandworm digging (expressed as the number of low tide periods occurring since the last low tide dug) were 5.3 and 3.4, respectively. The numbers of years of digging experience recorded for bloodworm and sandworm diggers show that worm digging is frequently a short-lived work experience, 35-51 percent of the bloodworm diggers and 22-34 percent of the sandworm diggers have dug between 1 and 4 years. The mean age of bloodworm and sandworm diggers varied between 27.7 and 31.9. The vast majority of both bloodworm and sandworm diggers are male.

NOAA Technical Report NMFS SSRF-768. Theroux, Roger B., and Roland L. Wigley. "**Distribution and abundance of east coast bivalve mollusks based on specimens in the National Marine Fisheries Service Woods Hole collection**." June 1983, xvi + 172 p., 121 figures, 327 tables.

ABSTRACT

The distribution and numerical abundance of over 108,000 specimens of bivalve mollusks (81 percent of which were alive when captured) collected and maintained by the Benthic Dynamics Investigation at the NMFS Northeast Fisheries Center at Woods Hole, Mass., are presented. They are illustrated in a series of charts, and their bathymetric range and bottom sediment preferences are outlined in tabular form. Taxonomic groups represented include 5 subclasses, 8 orders, 46 families, 99 genera, and 164 species. The specimens are contained in 10,465 lots from 2,767 sampling sites along the east coast continental shelf and slope, and upper continental rise between Nova Scotia and southern Florida. Samples range in depth from 0 to nearly 4,000 m. The collections were obtained by a variety of research vessels and persons using quantitative and qualitative sampling devices (i.e., grabs, dredges, trawls, etc.) over a period of 21 years. Also included are current vernacular names, zoogeographic data, and a reference to the original description of represented species. The data upon which this report is based are stored on magnetic tape and disc files, and the specimens are stored in a Specimen Reference Collection at the Northeast Fisheries Center in Woods Hole, Mass.

NOAA Technical Report NMFS Circular 448. Darcy, George H. "**Synopsis of biological data on the grunts *Haemulon aurolineatum* and *H. plumieri* (Pisces: Haemulidae)**." February 1983, iv + 37 p., 33 figures, 26 tables.

ABSTRACT

Information on the biology and fishery resources of two common species of western Atlantic grunts, *Haemulon aurolineatum* and *H. plumieri*, is reviewed and analyzed in the FAO species synopsis style.

NOAA Technical Report NMFS Circular 449. Darcy, George H. "**Synopsis of biological data on the pigfish, *Orthopristis chrysoptera* (Pisces: Haemulidae)**." March 1983, iv + 23 p., 22 figures, 15 tables.

ABSTRACT

Information on the biology and resources of the pigfish, *Orthopristis chrysoptera* is reviewed and analyzed in the FAO species synopsis style.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

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Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

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Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

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